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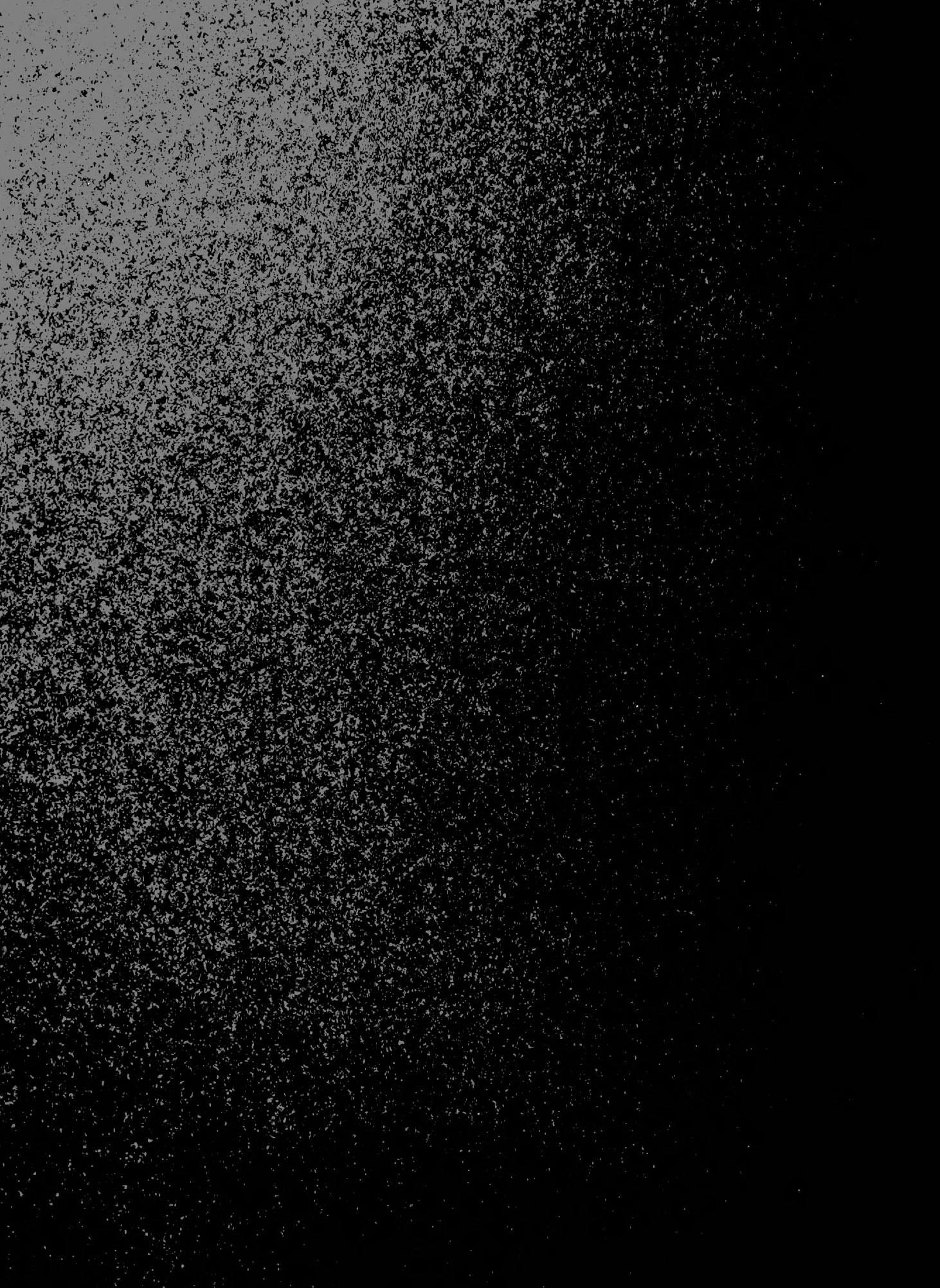
SUGARBEET RESEARCH

1998 REPORT



FOREWORD

SUGARBEET RESEARCH is an annual compilation of progress reports concerning research by U. S. Department of Agriculture, Agricultural Research Service investigators and other cooperators who are engaged in sugarbeet research. The report was assembled and produced at the expense of the Beet Sugar Development Foundation, and is for the sole use of its members and the cooperators. Much of the data has not been sufficiently confirmed to justify general release and interpretations may be modified with additional experimentation. This report is not intended for publication and should not be used for cited reference nor quoted in publicity or advertising. Reproduction of any portion of the material contained herein will not be permitted without the specific consent of the contributor and the Beet Sugar Development Foundation.

The report presents results of investigations strengthened by contributions received under Cooperative Agreement between the USDA Agricultural Service and the Beet Sugar Development Foundation, along with the California Beet Growers Association, the Western Joint Research Committee, the Sugarbeet and Education Board of Minnesota and North Dakota, and Texas A & M University.

Trade names occur in this report solely to provide specific information and do not signify endorsement by the U. S. Department of Agriculture, Texas A & M University, the Beet Sugar Development Foundation or any of the cooperating organizations.

CONTENTS

CONTENTS

CONTENTS

CONTENTS

CONTENTS

PAGE

SECTION G -- BELTSVILLE, MARYLAND

SUGARBEET RESEARCH

1998 REPORT

Section A

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California Beet Growers Association
California Industry Research Committee
Western Sugar Growers Research Committee

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CONTENTS

ABSTRACTS OF PAPERS PUBLISHED OR APPROVED FOR PUBLICATION, 1998

FRANCIS, S.A., M. REDFEARN, D.M. CHWARSZCZYNSKA, M.J.C. ASHER and R.T. LEWELLEN. Use of molecular markers in breeding for disease resistance in sugar beet (*Beta vulgaris* L.). Aspects of Applied Biology. 52: 279-285. 1998.

Disease resistance in sugar beet has been improved by conventional breeding, mostly based on the selection of resistant plants after field or glasshouse testing. However, there are still some diseases for which there is either no, or inadequate, resistance in commercial cultivars, mainly because the inoculation methods, and subsequent measurement of resistance are too difficult, slow or laborious to be used in a commercial breeding programme. In such cases, the use of molecular markers represents a means of selecting for disease resistance.

In this paper, the development and testing of an amplified fragment length polymorphism (AFLP) marker for beet necrotic yellow vein virus (BNYVV) resistance gene *Rz* is used as an example to show the advantages of marker-based selection for disease resistance. We have developed an AFLP marker linked 7.6cM from *Rz* in coupling phase. The marker was used for a comparative study of the efficacy of marker-based tests for BNYVV resistance and an ELISA test, which measured virus content. The marker gave better discrimination of resistant from susceptible plants than the ELISA because the ELISA could not identify susceptible disease escape plants. Use of the marker in an investigation of different sources of BNYVV resistance showed that they did not all contain *Rz*, suggesting that BNYVV resistance may be controlled by a range of resistance genes. The development of molecular markers specific for other resistance genes would allow the combination of many such genes in the same plant and would increase the durability of resistance to BNYVV.

KARASEV, A.V., O.V. NIKOLAEVA, R.F. LEE, G.C. WISLER, J.E. DUFFUS and W.O. DAWSON. Beet yellow stunt virus coat protein gene: expression in vitro and in vivo. Phytopathology. 88:1040-1045. 1998.

The beet yellow stunt virus (BYSV) genome contains at least nine open reading frames (ORF's) that code for proteins ranging from 6 to 66 kDa. Based on amino acid sequence comparisons, the coat protein (CP) was previously identified as the product of ORF7. We expressed the product of ORF7 in bacteria and confirmed that ORF7 codes for the BYSV CP by immunoblotting. BYSV is a phloem-limiting virus, and virus CP antigen of a quality sufficient for diagnostic antisera production has not been available. To produce BYSV antigen free of plant host contaminants, ORF7 was cloned into a pMAL bacterial expression vector. The resulting fusion protein was affinity-purified and used as an antigen to raise anti-BYSV CP antisera in rabbits and guinea pigs. Using these antisera, an indirect double-antibody sandwich (DAS) enzyme-linked immunosorbent assay (ELISA)-based diagnostic system was developed. This indirect DAS-ELISA format enabled reliable detection of BYSV in tissue extracts from virus-infected lettuce diluted up to 5,000 times. The diagnostic system developed may enable large-scale epidemiological studies of BYSV using simple serological techniques. The antisera raised had a titer exceeding 1×10^5 in immunoblots and easily detected the 23.7-kDa BYSV CP

in virus-infected lettuce and sowthistle plants. In these two plant species, BYSV CP was detected as two closely migrating bands during electrophoresis, which may suggest posttranslational CP modifications. To further characterize the BYSV CP gene, the 5'-untranslated region (UTR) of the BYSV CP subgenomic RNA (sgRNA) was cloned and sequenced. The CP-encoding, approximately 1.9-kb sgRNA has an AT-rich, 66-nucleotide-long 5'-UTR colinear to the genomic sequence upstream of ORF7.

LECOQ H., G. WISLER and M. PITRAT. Cucurbit viruses: the classics and the emerging. p. 126-142 in: McCreight, J. D., Proc. Cucurbitaceae 98; Evaluation and Enhancement of Cucurbit Germplasm. ASHS Press, Alexandria Va. 1998.

Viral diseases cause important economic losses in cucurbit crops throughout the world. In the major growing regions, cucurbit viruses represent a complex and changing pathosystem. Several viruses often develop, concomitantly or successively, severe epidemics within a single crop. Among the 35 well-characterized viruses infecting cultivated *Cucurbitaceae* some have been known for a long time (the classics) while others have been spreading and causing serious damage only recently (the 'emerging'). A brief description is provided for each of these viruses along with their distribution, and discussion of the threat they pose to cucurbit crop production. The availabilikty of resistances to these viruses in the four major cultivated cucurbit species (cucumber, melon, squash and watermelon) is also discussed.

LEWELLEN, R.T. Registration of 10 Sugarbeet Germplasm C890 Lines with Resistance to Rhizomania. Crop Sci. 38:902-903. 1998.

Sugarbeet (*Beta vulgaris* L.) germplasm lines C890-1, C890-2/3, and C890-4 through C890-11 (Reg. No. GP-190 to GP-191; PI 593701 to PI 593704, PI 595749 to PI 595750, PI 593706 to PI 593707, and PI595751 to PI 595752)(Table 1) were developed by the USDA-ARS in cooperation with the Beet Sugar Development Foundation and the California Beet Growers Association and released in 1996. These lines have C790 (5) genetic background plus resistance to rhizomania caused by beet necrotic yellow vein virus (BNYVV). Each line in the C890 series had a different initial nonrecurrent source that had been identified as having resistance to rhizomania (2). C790 is a monogerm, O-type, self-fertile, genetic male-sterile facilitated random-mated population that had been improved by five cycles of the S_1 progeny recurrent selection. C790 is believed to be uniformly susceptible to rhizomania. C790 is the source of several monogerm parental lines (1). The C890 lines are the monogerm counterparts to the multigerm C79 series (3). Lines in the C890 series will segregate for resistance to rhizomania and for monogerm, O-type, and genetic male-sterile traits. These lines should facilitate selection of rhizomania resistant, monogerm, O-type breeding and parental lines.

From the early-generation backcross lines that were subsequently released as C79-1 through C79-11 (3), plants resistant to rhizomania were selected and pair-crossed in the greenhouse under paper bags to genetic male-sterile, monogerm plants from C790. One or more backcrosses were made to C790 with resistant plants selected from each BC_nF_1 generation. Resistance to rhizomania was determined in 4-mo-old plants grown in BNYVV infested soil (2,3). Under these conditions, escapes were common, which led to lower than expected frequency of resistant plants in the subsequent generation. Traits other than resistance to rhizomania were largely

disregarded. Thus, the C890 lines continue to segregate for multigerm types. Following the final backcrosses, resistant plants within each line were increased in bulk.

Table 1 lists the pertinent information for each line. As with the C79 series, sources of resistance included sugarbeet, Swiss chard, and weed and wild beet (*B. vulgaris* L. subsp. *maritima*). The allelism or relationship among these sources has not been fully determined, but some do appear to involve the same DNA markers (6). Line C890-8 with resistance from C50 appears to offer the greatest improvement in resistance to rhizomania over that conditioned by the *Rz* allele (2). In Imperial Valley (California) tests under combined effects of rhizomania and high temperature, the resistance factor or factors in C890-8 provided the highest level of protection and survivability (4).

LEWELLEN, R.T. Registration of C76-89-5 Parental Line of Sugarbeet. Crop. Sci. 38:905. 1998.

Sugarbeet (*Beta vulgaris* L.) parental line C76-89-5 (Reg. No. PL-37, PI593698) was developed by the USDA-ARS in cooperation with the Beet Sugar Development Foundation and the California Beet Growers Association. This line was released in 1996. C79-89-5 combines well with monogerm testers and for combined resistance to bolting and diseases that are prevalent in the western USA. It is adapted throughout California.

C76-89-5 is a multigerm, self-sterile line descended from the single full-sib (FS) family. The FS from which C76-89-5 was derived was one of six that were selected from a larger set and recombined to produce C76-89 (PI578087) released in 1993. These original FS families were obtained from pair crosses between individual plants of C31-89(2) crossed to individual plants from a line similar to C82(1). Following the initial FS progeny tests, selected FS families were increased and simultaneously crossed to a monogerm tester. These experimental hybrids were evaluated in trials at Salinas and Brawley, CA. Based on these trials, the increase of the FS that became C76-89-5 was selected. Following increase, this line underwent one cycle of individual plant selection for combined nonbolting tendency and multiple disease resistance. Twelve-month-old plants from an overwintered planting in soil highly infested with beet necrotic yellow vein virus (BNYVV), which causes rhizomania, were selected for nonbolting, root size and shape, and relative absence of foliar and root disease symptoms. At 6 mo of age, these plants had been inoculated with *Erwinia carotovora* (Jones) Bergey et al. subsp. *betavasculorum* Thomson et al. Natural infection with powdery mildew (caused by *Erysiphe polygoni* DC.) was not controlled. After the initial field selection for nonbolting and disease resistance, the beets were reselected based on individual root sucrose concentration. During development and testing, C76-89-5 was identified as R76-89-5.

C76-89-5 appears to have merit as a candidate pollinator of commercial hybrids, in that it imparts to its hybrids both high sugar concentration and high sugar yield. These trials, however, were run under conditions in which moderate disease pressure could enhance the apparent performance relative to the more susceptible commercial checks. C76-89-5 has the highest level of resistance known to virus yellows. For the beet yellows virus (BYV) component of virus yellows, resistance is moderate. For beet western yellows virus (BWYV) and other similar luteoviruses, C76-89-5 has high resistance. C76-89-5 has a high frequency of the *Rz* allele tht conditions resistance to BNYVV. It is highly resistant to sugarbeet erwinia root rot and

moderately resistant to powdery mildew. It is a nonbolting type under California conditions. C76-89-5 is moderately susceptible to beet curly top virus (BCTV). It has a small, compact, dark-green canopy and smooth roots with moderately low soil tare. It is a narrowly based line with the genetic variability that can be ascribed to a full-sib family and could be improved for some traits by continued selection.

LEWELLEN, R.T. and S.R. KAFFKA. Registration of C913-70 Sugarbeet Germplasm. Crop. Sci. 38:903. 1998.

Sugarbeet (*Beta vulgaris* L.) germplasm line C913-70 (Reg. No. GP-189, PI593691) was developed by the USDA-ARS and the California Agricultural Experiment Station in cooperation with the Beet Sugar Development Foundation and the California Beet Growers Association. It was released in 1996. C913-70 is a multigerm, self-fertile line with green hypocotyls and segregates for genetic male sterility (*aa*). It is a narrowly based line descended by bulk increases from one S_1 progeny line. The second and third increases were from roots mass-selected for resistance to rhizomania caused by beet necrotic yellowvein virus (BNYVV). The S_1 line was produced by selfing in the greenhouse one mother root selected for resistance to rhizomania from Population 913.

Population 913 is a multigerm, self-fertile, genetic male-sterile, facilitated random-mated population similar to C918 (PI578079) released in 1993 that was undergoing population improvement. The S_1 line was selected based on performance and nonbolting in an S_1 progeny test. Experimental hybrids were produced in conjunction with subsequent seed increases. The line and experimental hybrids were evaluated in replicated field trials at Salinas, Davis, and Brawley, CA. On the basis of these tests, C913-70 was selected from a set of sister lines as having the best combination of yield and disease resistance. C913-70 has been tested as breeding line 913-70.

Relative to similar material, C913-70 has good general combining ability for sugar yield, and its hybrids are usually E-types for sucrose concentration. It has resistance to bolting in fall-winter plantings and to erwinia root rot [caused by *Erwinia carotovora* (Jones) Bergey et al. subsp. *betavasculorum* Thomson et al.] in wound-inoculated evaluation. The *Rz* allele for resistance to rhizomania occurs at a high frequency. C913-70 is moderately resistant to powdery mildew (caused by *Erysiphe polygoni* DC.) and moderately susceptible to beet curly top virus (BCTV). C913-70 has light green leaves that belies its moderate resistance to virus yellows caused by beet yellows virus (BYV) and beet western yellows virus (BWYV). It appears to have high resistance to the BWYV component. C913-70 is uniform and has low to moderate vigor. In the bolted, seed production phase, its seed stalks are bushy and usually shorter than standard monogerm parental lines. Except for the genetic male-sterile segregates, it has good pollen production.

C913-70 should be tested for its potential as a parental line to produce combined disease and bolting resistant hybrids. The hybrids of C913-70 may meet the requirements for fall and spring planted, overwintered productions where high pressure exists for rhizomania, erwinia, and bolting and where moderate levels of curly top and virus yellows resistances are desirable. Because C913-70 segregates for genetic male sterility, it potentially could be used as the C-parent to produce double-cross hybrids when there would be an advantage to combine different

sources of resistance and factors for productivity. It also may be useful as a germplasm line to generate new breeding material.

LEWELLEN, R.T. and J.K. SCHRANDT. Inheritance of resistance to powdery mildew in sugarbeet derived from *Beta maritima*. J. Sugar Beet Research. 1999. (in press).

Powdery mildew of sugarbeet (*Beta vulgaris* L.) caused by *Erysiphe polygoni* DC. was introduced into N. America in 1974. Since, it has remained a persistent problem. Traditional American germplasm, e.g., curly top resistant breeding lines, were largely susceptible. Chemical control and partial resistance are used to help control losses. High resistance was observed at Salinas in *B. vulgaris* spp. *maritima* accessions WB97 and WB242. In a preliminary investigation, this wild beet resistance was backcrossed into sugarbeet where reaction to *E. polygoni* among individual plants was expressed in more-or-less discrete resistant susceptible classes. Plants from these backcross derived lines were used in controlled crossing designs to obtain testcross and selfed families for genetic analysis. In 1997 these families were scored for reaction to powdery mildew under natural field conditions at Salinas. Their segregation fit the pattern expected for a single, dominant gene for resistance to powdery mildew. The gene symbol *Pm* is proposed for this resistance factor. In field tests in 1998, the identical testcross families showed different segregation patterns. The possible reasons for these differences will be discussed.

LEWELLEN, R.T., G.C. WISLER, H.-Y. LIU, S.R. KAFFKA, J.L. SEARS and J.E. DUFFUS. Reaction of sugarbeet breeding lines and hybrids to beet chlorosis luteovirus. J. Sugar Beet Research (in press). 1999.

Virus yellows is a complex of aphid vectored viruses that may include beet yellows, beet western yellows (BWYV), beet mosaic, and in Europe, beet mild yellows (BMYV) viruses. Recently, a new luteovirus of sugarbeet was recognized in California, Texas, Colorado, and Nebraska that is similar to BWYV and BMYV. It has been named beet chlorosis virus (BChV). BChV has a different host range than BWYV or BMYV. The host range of BChV includes *Chenopodium capitatum* causing leaves to turn red which led to the virus affectionately being called "capitatum red." On sugarbeet, foliar symptoms are similar to BWYV but with a tendency for greater interveinal yellowing with distinct green veins. BChV was used in 1997 to inoculate sugarbeet variety trials at Salinas and Davis, California to determine its effects on yield and the occurrence of differential host-plant reactions. The yield reduction caused by BChV was similar but probably more severe than that caused by BWYV. Sugar yield losses ranged from about 5 to 40%. In general, the reactions fit the loss pattern known for BWYV and BMYV. Lines and hybrids from the virus yellows resistance breeding program at Salinas tended to show the most resistance. The most susceptible commercial hybrids tested were those that have been grown in Colorado and Nebraska where BChV has caused significant damage in several recent years.

LIU, H.Y., G.C. WISLER and J.E. DUFFUS. Abutilon yellows virus -A new closterovirus transmitted by banded-wing whitefly (*Trialeurodes abutilonea*). In Abstracts volume 2, 1.11.8, 7th International Congress of Plant Pathology, Edinburgh, Scotland, 9-16 August 1998.

A virus, first discovered on velvetleaf (*Abutilon theophrasti*) in Illinois, has been maintained in greenhouse culture since 1977. Recent studies on the virus, designated as abutilon yellows virus (AYV), have shown that leaf dips and purified preparations contained long, flexuous, filamentous particles approximately 850-900 X 12 nm. The virus was transmitted by the banded-wing whitefly (*Trialeurodes abutilonea*) in a semipersistent manner and retained by the vector for four days. The virus has an apparently narrow host range and could not be mechanically transmitted. Inclusion bodies, characteristic of closteroviruses, were consistently associated with the phloem of AYV-infected *Nicotiana clevelandii*. Abutilon yellows virus was cloned with dsRNA isolated from AYV-infected *N. clevelandii* as a template. These clones specifically reacted with dsRNA, as well as with total nucleic acids extracted from AYV-infected plants in dot blot analyses. No reactions were observed in dot blots against uninfected host plants and other known whitefly transmitted closteroviruses.

LIU, H.Y., G.C. WISLER and J.E. DUFFUS. A new bipartite genome closterovirus transmitted by banded-wing whitefly (*Trialeurodes abutilonea*). Proc. 9th Conference of ISHS Working Group on Vegetable Viruses. pg. 77. Torino, Italy, August 22-27, 1998.

Whitefly-transmitted bipartite closteroviruses continue to grow. The closteroviruses have been characterized by a number of features including particle morphology, cytopathology, mode of transmission, and more recently, genome organization. Abutilon yellows virus (AYV) was first found on velvetleaf (*Abutilon theophrasti*) in Illinois, has been maintained in greenhouse culture by whitefly transmission since 1977. However, this virus has never been characterized. The purpose of the research on the AYV agent was to verify evidence of its viral nature, to measure some of its properties, to investigate its relationship with its whitefly vector and the relationship with other whitefly-borne closteroviruses. Recent studies on the virus have shown that leaf dips and purified preparations contained long, flexuous, filamentous particles approximately 800-850 X 12 nm. The virus was transmitted by the banded-wing whitefly (*Trialeurodes abutilonea*) in a semipersistent manner and retained by the vector for four days. The virus has an apparently narrow host range and could not be mechanically transmitted. Inclusion bodies, characteristic of closteroviruses, were associated with the phloem of AYV-infected *Nicotiana clevelandii*. Ultrastructural studies of infected tissue revealed the consistent presence of cytoplasmic vesicles in phloem parenchyma cells characteristic of closterovirus infections. AYV was cloned using dsRNA isolated from AYV-infected *N. clevelandii* as a template. These clones specifically reacted with dsRNA, as well as with total nucleic acid extracts from AYV-infected plants in dot blot analyses. No reactions were observed in dot blot hybridizations against uninfected host plants and other known whitefly transmitted closteroviruses. Double stranded RNA analyses of AYV show two prominent dsRNA of approximately 7,800 and 8,200 bp. Digoxigenin-11-UTP-labeled riboprobes derived from cDNA clones were used in Northern blot hybridizations to detect these two nonhomologous dsRNA. Based on particle morphology, whitefly-transmission, cytopathology, and phloem-limitation, AYV appears to be another member of whitefly-transmitted bipartite closteroviruses. Currently, only diodia vein chlorosis virus and tomato chlorosis virus have been reported to be transmitted by the banded-wing whitefly. However, these two viruses differ significantly from AYV in host ranges and nucleic acid hybridizations.

LIU, H.Y., G.C. WISLER, J.L. SEARS and J.E. DUFFUS. Beet chlorosis virus - A new luteovirus affecting sugarbeet. J. Sugar Beet Research (in press). 1999.

A yellowing disease of sugarbeet has been frequently observed in Colorado, Nebraska, Texas, and California sugar beet fields since early 1990s. Symptoms of this disease are identical to those caused by beet western yellows virus (BWYV) including interveinal yellowing, thickening and brittleness of older leaves and necrotic lesions caused by *Alternaria* sp. BWYV has a wide host range and is readily distinguished by systemic infection of shepherd's purse (*Capsella bursa-pastorus*) and lack of infection of *Chenopodium capitatum*. These newly described isolates have a narrow host range and show interveinal reddening on *C. capitatum* but do not infect shepherd's purse. This disease is readily transmitted in a persistent manner by the green peach aphid (*Myzus persicae*), but is not mechanically transmissible. The virus has been purified and the isometric virus particles are 26 nm in diameter. The coat protein from purified preparations is ca. 23 kDa. Serological analysis and biological properties indicate that the virus is distantly related to, but distinct from BWYV. We proposed to name this virus beet chlorosis virus.

WINTERMANTEL, W.M. and J.L. SEARS. Examination of viral interactions in relation to disease severity and resistance in the virus yellows complex of sugarbeet. Phytopathology 89: (in press). 1999.

Virus yellows is a disease complex composed of different genera of plant viruses. Beet yellows closterovirus (BYV), beet western yellows luteovirus (BWYV), and occasionally, beet mosaic potyvirus (BtMV), are the main components. BtMV alone may not contribute to economically significantly disease loss. All of these viruses are transmitted by aphids, and all are usually present at some level in infected fields. Although beet-free periods are useful in managing virus yellows, the increased range and population of the black bean aphid has made this disease more difficult to control in recent years. In this study, sugarbeet varieties exhibiting differential levels of resistance to the yellows complex viruses were inoculated with every possible combination of one, two or all three viruses. Interviral effects were identified and correlated using quantitative molecular techniques. Correlation of stunting and symptom severity with different virus combinations indicate that disease is more severe when all three viruses are present than when plants are infected by one or any combination of two viruses.

WISLER, G.C. Furoviruses. Chapter in Encyclopedia of Plant Pathology, John Wiley & Sons, New York (in press). 1999.

Furoviruses

Like other virus taxonomic groups, the *Furovirus* genus has been reorganized over recent years. This is due primarily to a shift in taxonomic characteristics that are considered, for purposes of classification, from primarily biological and serological to primarily molecular. For example, the genus *Furovirus* was originally named to include those plant viruses that were transmitted by fungi (fu) and had a rigid, rod-shaped (ro) morphology. These viruses also were known to possess a divided genome. A new classification has been proposed which splits the *Furovirus* genus into four separate genera which have been accepted by the International Committee on Taxonomy of Viruses (ICTV). The new genera are (i) the *Furovirus* genus which includes soil-borne wheat mosaic virus (SBWMV), oat golden stripe virus (OGSV), and sorghum chlorotic spot virus (SCSV) (ii) the *Pomovirus* genus which includes potato mop-top virus (PMTV), beet soil-borne virus (BSBV), and broad bean necrosis virus (BBNV), (iii) the *Pecluvirus* genus,

which includes peanut clump virus (PCV) and Indian peanut clump virus (IPCV), and (iv) the *Benevirus* genus, which includes beet necrotic yellow vein virus (BNYVV) and beet soil-borne mosaic virus (BSBMV) (a new virus recently described infecting sugarbeet). The common characteristics among these viruses include transmission by plasmodiophorid fungi, a rigid, rod-shaped particle morphology, and possession of a divided genome. The original *Furovirus* genus now consists of four different genera, with distinctions made based on genomic properties which are still being elucidated. In some cases, the fungal vector is still not known. The particle morphology of these new genera is similar to that of the Tobamo-, Tobra- and Hordeivirus Genera.

WISLER, G.C., J.E. DUFFUS, H.-Y. LIU and A.V. KARASEV. Distinguishing characteristics of some new whitefly-transmitted criniviruses infecting tomato. Proc. 9th Conference of ISHS Working Group on Vegetable Viruses. pg. 1. Torino, Italy, August 22-27, 1998.

Two whitefly transmitted (WFT) bipartite viruses infecting tomato which belong to the new Genus Crinivirus have been studied with respect to biological and molecular characteristics. Tomato infectious chlorosis virus (TICV) was first found in 1993 infecting field-grown tomatoes in California, and caused a $2 million loss to production that year. TICV is transmitted by the greenhouse whitefly (GHWF) (*Trialeurodes vaporariorum*) and is retained up to 4 days. Its host range includes 26 species in 8 families of crop, weed, and ornamental species. Tomato chlorosis virus (ToCV) was first detected in 1996 from Florida greenhouse production tomatoes. ToCV is transmitted by the GHWF, *Bemisia tabaci* biotypes A and B, and the banded wing whitefly (*T. abutilonea*) and is retained for 24 hours in the vector. ToCV also has a moderate host range of 24 species in 7 families. TICV has been found in California, North Carolina, and Italy whereas ToCV has been found in Florida, Colorado, and Louisiana. Particle measurements for TICV and ToCV are within the range for bipartite closteroviruses (12x850-900, 12x800-850 nm, respectively) as are sizes of the dsRNAs (7.8 and 7.4; 8.2 and 7.8 kbp, for RNA 1 and 2, respectively). Northern blot hybridizations show no detectable homology between the viral RNAs or between the two viruses. Phloem limited cytoplasmic inclusions and vesicles are produced by TICV and ToCV. Antiserum to TICV gives only slightly elevated absorbance (A_{405} nm) readings in DAS-ELISA and extremely faint reactions in western blots against ToCV-infected plant tissues, and indicates the coat protein molecular mass (ca. 31 kDa) is the same for TICV and ToCV. Degenerate primers designed to amplify a portion of the HSP70 coding region of the WFT closteroviruses amplified a 650 bp product of TICV but failed to amplify that region of ToCV due to differences at 3 nondegenerate positions. The 1a/1b ribosomal frameshift region of TICV RNA 1 is like LIYV with an overlapping lysine codon ("slippery sequence"; Klaassen, 1996). Like LIYV, TICV and ToCV contain a 9 amino acid overlap at the frameshift, but ToCV does not contain an overlapping lysine codon. A third distinct bipartite WFT-crinivirus has recently been identified infecting tomato. The movement of tomato and other crops and ornamental germplasm with accompanying vectors play an important role in the distribution and incidence of this growing group of WFT viruses.

WISLER, G.C., R.T. LEWELLEN, J.L. SEARS, H.-Y. LIU and J.E. DUFFUS. Differences in beet necrotic yellow vein virus (BNYVV) levels among susceptible and resistant sugar beet cultivars grown in the United States. J. Sugar Beet Research (in press). 1999.

The content of BNYVV in sugar beet roots from representative commercial and experimental cultivars developed for production in the United States was measured by a triple antibody sandwich ELISA (TAS-ELISA). A monoclonal antibody to BNYVV was used as the trapping antibody and a polyclonal antibody made from an *in vitro* expressed capsid protein of BNYVV for the detecting antibody. Differences in absorbance ($A_{405\ nm}$) values measured among the eight cultivars closely corresponded to a dosage effect and to the frequency of the *Rz* allele that conditions resistance to BNYVV. A diploid (*Rzrz*) hybrid had a significantly lower value than a similar triploid (*Rzrzrz*) hybrid. Cultivars that segregated (*Rzrz:rzrz*) had higher absorbance values than uniformly resistant (*Rzrz*) hybrids. For all cultivars, differences were observed among the three harvest dates, with progressively lower absorbance values obtained as the season progressed. A strong positive correlation was observed between absorbance values and the rhizomania disease index scores, whereas a negative correlation was observed between absorbance and individual root weight, plot root weight, and sugar yield. These results are important in plant breeding, varietal development, and cultivar evaluation. They show that the breeder or agronomist can be fairly confident of measuring varietal reactions to rhizomania by either scoring or weighing field grown material. This information is useful in resistance breeding and evaluation programs and for the sugar industry in consideration of cultivar choice, inoculum production, and rotations for future cropping.

PAPERS PUBLISHED SINCE ABSTRACTED IN PREVIOUS REPORT

WISLER, G.C., R.T. LEWELLEN, J.L. SEARS, H.Y. LIU and J.E. DUFFUS. Levels of beet necrotic yellow vein virus among resistant and susceptible sugarbeet cultivars grown in rhizomania infested field plots. Proc. 7th Intl. Cong. Plant Path. Edinburgh, Scotland. 1998. 1.11.13. 1998.

WISLER, G.C., R.H. LI, H.-Y. LIU, D.S. LOWRY and J.E. DUFFUS. Tomato chlorosis virus: a new whitefly-transmitted, phloem-limited, bicomponent closterovirus of tomato. Phytopathology 88:402-409. 1998.

DEVELOPMENT OF SUGARBEET BREEDING LINES AND GERMPLASM

R.T. LEWELLEN

CP01 & CP02 - CP01 & CP02 are self-sterile, multigerm, germplasm lines that segregate for resistance to powdery mildew caused by *Erysiphe polygony*. CP01 and CP02 have identical developmental histories except for the source of resistance to powdery mildew. Resistance within CP01 was from WB97 and CP02 was from WB242. High resistance to powdery mildew was identified in WB97 and WB242 separately by J.S. McFarlane and E.D. Whitney at Salinas, CA. WB97 was described by McFarlane as an annual *Beta vulgaris* spp. *maritima* line. Seed was obtained from Japan Sugarbeet Improvement Foundation in 1968. Passport information indicated that WB97 was a *B.patula* line sent to Japan from Wageningen, The Netherlands, as WB46 in 1963. The site of its original collection is not known. Seed of WB242 was obtained from Bergen op Zoom, The Netherlands, in 1974 as a *B.v.maritima* line. WB242 was originally collected from the Loire River estuary in France. It is also known to have low sugarbeet cyst nematode (SBCN) counts and may be the same or similar as the lines known as Le Pouliguen Group 2 and to (PI198758-59). In tests at Salinas, WB242 was highly variable for plant type, red pigmentation, bolting habit, and root type.

In order to enhance sugarbeet with the high resistance to powdery mildew found in WB97 and WB242 and to study the inheritance of powdery mildew resistance, powdery mildew resistance was backcrossed into sugarbeet line C37. C37 is uniformly and highly susceptible to powdery mildew, completely self-sterile under Salinas greenhouse conditions, and has only green hypocotyls. These traits facilitate making and recognizing the F_1 hybrids in each generation. Resistance from WB97 and WB242 was maintained in separate but parallel sets of crosses. Usually C37 was used as the female parent so CP01 and CP02 have sugarbeet cytoplasm. CP01 and CP02 are initially being released as the BC_4F_2 generation. BC_4F_1 testcrosses of these lines were evaluated in the field in 1997 and are known to segregate for reaction to powdery mildew. Unselected stecklings of these BC_4F_1 testcrosses were increased in mass to produce lines P813 and P814 released as CP01 and CP02, respectively. Previously, these lines have been evaluated as P403 and P603 and P404 and P604. Genetic studies in 1997 showed that resistance to rhizomania is inherited in the manner of a singly dominant allele from each wild beet source. This resistance has tentatively been assigned the *Pm* gene symbol but the precise allelism between the WB97 and WB242 resistances has not been determined.

CP01 and CP02 are susceptible to rhizomania caused by beet necrotic yellow vein virus. Likewise, they should be similar to the C37 recurrent parent for other traits. Several of the BC_4F_1 testcrosses segregated for annualism so this trait may remain at a low frequency in these lines. No attempt has been made to determine if any variability for SBCN resistance remains from WB242. CP01 and CP02 should be useful as enhanced sources of resistance to powdery mildew originally found in *B.v.maritima* and for genetic research.

C26 - C26 is a multigerm, self-sterile line that theoretically is 50% sugarbeet and 50% *Beta vulgaris* L. spp. *maritima*. The wild beet *B.v.maritima* was principally derived from accessions collected by Dr. D. Doney *et al.* in France, UK, and Ireland. C26 was developed from crosses between sugarbeet line C37 and *B.v.maritima*. The sources of the *B.v.maritima* plants were from PI's tested in the 1991 and 1993 Commodity Germplasm Committee (CGC) sponsored tests at Salinas. Plants from within individual PI's that showed high resistance to rhizomania caused by beet necrotic yellow vein virus were selected. In 1991, about 200 plants from about 20 accessions collected in the UK and 6 lines collected in Ireland were bulked and increased in mass in 1992 to produce a *B.v.maritima* population called R223. In 1993, about 160 rhizomania resistant plants from about 11 PI lines collected in France were bulked. Stecklings from population R223 and the bulked selected plants from the French accessions were combined into a single pollinator in 1994 and crossed in bulk toC37. C37 is uniformly susceptible to rhizomania and has only green hypocotyls. Seed harvested from the C37 seed bearing plants was sown in August 1994 into a field plot with rhizomania infestation. In December 1994, F_1 plants were selected based upon resistance to rhizomania and the red hypocotyl markers of *B.v.maritima*. These selected F_1 plants were increased by open pollination to produce an F_2 population called R526. Records were not maintained as to the contribution of each wild beet accession or which accessions were involved. The UK accessions were in the PI518298-518372 (WB620-694) series. The Irish accessions were in the PI517301-518416 (WB703-738) series. The French accessions were in the PI518598-518608 (WB852-862) series. What these *B.v.maritima* plants had in common was resistance to rhizomania.

Plants from the F_2 population were grown in the field under rhizomania infested conditions and were inoculated with virus yellows caused by beet yellows virus and beet western yellows virus, *Erwinia carotovora* spp. *betavasculorum*, and powdery mildew caused by *Erysiphe polygony*. Individual plants were selected for resistance to rhizomania, nonbolting, root conformation, root size, and sucrose concentration. Selected roots were increased in mass by open pollination to produce F_3 line R726. R726 was again selected under field conditions for resistance to rhizomania, nonbolting, and root conformation and size and increased to produce the F_4 line R926 that is being released as C26.

The F_3 line R726 has been evaluated in field trials at Salinas and Brawley, CA. R726 has shown high resistance to rhizomania. Most plants appear to be biennial or hard bolting annuals. Pigmentation is mostly similar to that of sugarbeet but some *B.v.maritima* patterns still occur. Under rhizomania and/or virus yellows conditions, the components of yield are similar to other open-pollinated lines of sugarbeet. Under VY infected conditions, R726 has yellowing symptoms that score similar to the most tolerant sugarbeet lines. Under mild Cercospora leaf spot epiphytotic at Salinas, R726 was moderately resistant. C26 has dark green canopy, similar to the coloration of many *bvm* lines from NW Europe. C26 should be a broadly based population from which new genetic variability might be found for the future improvement of sugarbeet.

C829-3, C831-3, C831-4, C833-5, C833-12, C859-8, C864-14, C867-1, C891-10, & C911-4-7 - Monogerm, self-fertile, genetic-male-sterile facilitated, random-mated populations of sugarbeet that segregate for resistance to rhizomania (*Rz*) has been under development as part of a comprehensive breeding and population improvement program. From these populations and as part of the population improvement procedure, S_1 and other types

of progeny families have been generated. These progeny lines have been evaluated per se for reaction to diseases, bolting tendency, and agronomic traits, particularly sucrose content. Progeny lines with desirable combinations of traits have been recombined as part of the population improvement program and a few perceived elite lines have been topcrossed to produce experimental hybrids. The genetic male-sterile segregates within the selected progeny lines were used as the seed bearing parent. These topcrossed progenies were then tested to evaluate each line's hybrid performance.

The early generation, self-fertile (inbred) breeding lines listed below have been selected from these evaluations. These lines are being released from this program to allow testing under a wider array of pollinators, environmental conditions, and production practices. Currently, they are continuing to be evaluated in USDA tests at Salinas and Brawley, CA.

In general, these lines have similar histories and traits. They were originally started from selfed or sib-mated individual plants and have been increased one or more times. Except as noted, they are self-fertile (S^f) and segregate for genetic male sterility (A-:aa). They are monogerm and O-type or monogerm, O-types can be selected from them. They segregate for resistance to rhizomania (*Rz*). Their backgrounds come from the virus yellows and curly top resistance breeding programs. Most have fair to good nonbolting tendency and intermediate reactions to powdery mildew and Erwinia root rot.

At least the first cross to establish cytoplasmic male sterile (CMS) counterparts has been made. Small quantities of seed of these CMS versions were distributed with the released maintainers.

C829-3 was selected from population-829. Population-829 was developed from crosses between lines similar to C309 and C911-4. C829-3 segregates for hypocotyl color and O-type. Relative to most monogerm lines, it shows tolerance to virus yellows.

C831-3 and C831-4 were selected from population-831. Population-831 was developed from crosses between lines similar to C911-4 and a composite of monogerm, O-type, curly top resistant, nonbolting inbred lines such as C562, C546, C718, and C762-17. The intent of this population was to combine factors for resistance to rhizomania, curly top, and virus yellows. C831-3 and C831-4 appear to have tolerance to virus yellows. C831-3 is homozygous for red and is O-type. C831-4 is moderately resistant to *Erwinia*. C831-3 appears to have slightly better sugar content and yield and is more resistant to bolting.

C833-5 and C833-12 were selected from population-833. Population-833 was developed from a cross of population-867 to the same composite of monogerm inbred lines used for population-831. This population combines factors for resistance to rhizomania, curly top, and bolting. C833-5 showed the best combined sugar content and yield in progeny tests in 1997 and has moderately high nonbolting tendency. C833-12 showed less resistance to bolting. Both lines are homozygous for red hypocotyl color.

C859-8 was isolated from C859. It appears to combine resistance to rhizomania with good sucrose content. C859-8 has green hypocotyls and is O-type.

C864-14 was selected as a half-sib line from populaton-864. Population-864 was developed by backcrossing resistance to rhizomania (*Rz*) into population-767. C864-14 has mostly red hypocotyls and is O-type.

C867-1 was selected from populations-867. Like population-864, population-867 was a rhizomania resistant counterpart of population-767. Population-767 was developed from a population hybrid between population-755 (C310) and curlytop resistant line C546. C867-1 has shown good curlytop resistance in Idaho tests. It has mostly red hypocotyls and is O-type.

Monogerm lines segregating for resistance to rhizomania

Release No.	Source Population	Progeny[1] CMS[2]	Breeding Line No.
C829-3	829	S1	8829-3, 5829-3
C829-3CMS	C790-15CMS	1	8829-3H50
C831-3	831	S1	8831-3, 5831-3
C831-3CMS	C790-15CMS	1	8831-3H50
C831-4	831	S1	8831-4, 6831-4,5, 831-4
C831-4CMS	C911-4-7CMS	2	8831-4HO
C833-5	833	S1	8833-5, 5833-5
C833-5CMS	C790-15CMS	1	8833-5H50
C833-12	833	S1	8833-12, 5833-12
C833-12CMS	C790-15CMS	1	8833-12H50
C859-8	C859	S1[3]	6859-8, 2859-8
C859-8CMS	C859CMS	1	6859-8HO
C864-14	864	HS	7864-14, 5864-14, 3864-14
C864-14CMS	C790-15CMS	3	7864-14HO, 5864-14HO
C867-1	867	S1[3]	7867-1, 4867-1, 2867-1
C867-1CMS	C790-15CMS	2	7867-1HO, 4867-1H50
C891-10	891	S1[3]	6891-10, 2891-10
C891-10CMS	C890CMS	1	6891-10HO
C911-4-7	C911-4	S1	8911-4-7, 6911-4-7, 5911-4-7
C911-4-7CMS	C790-15CMS	4	8911-4-7HO, 6911-4-7HO

[1]Original progeny family (S_1 = family from selfed plant. HS = half sib).
[2]Crosses and backcrosses to CMS source.
[3]S1 made on unbagged plant in increase plot, therefore, could be mixed S1 and HS.

C891-10 was selected from population-891. Population-891 was developed from a population hybrid between population-876 and population-890 (C890). C891-10 has green hypocotyls and segregates for O-type.

C911-4-7 was a monogerm selection from line C911-4 that combined resistance to rhizomania and virus yellows. C911-4-7 appears to be self-sterile with some plants showing considerable pseudo-self-fertility. It is a poor O-type and segregates for hypocotyl color. It is moderately tolerant to virus yellows.

Suggested use of these lines is to increase and evaluate for hybrid performance under a range of environmental and production conditions. Those found potentially useful could be selected as needed for improved monogerm and O-type traits. Using conventional techniques or marker assisted selection, lines homozygous for Rz could be developed. One or more of these lines could be used as sources of combined disease resistance and/or recombined to develop a narrowly based monogerm, self-fertile, random-mated population with desirable combinations of disease resistance and hybrid performance characteristics. Relative performance of these lines can be reviewed in the annual Sugarbeet Research Reports (Bluebooks).

INDEX OF VARIETY TRIALS, SALINAS, CA, 1997-98 AT THE U.S. AGRICULTURAL RESEARCH STATION

Tests were located in three fields at Salinas and established at five planting dates. All tests except 998-2098 were under rhizomania infested conditions. Nortron, Pyramin, and Betamix were applied for weed control. Bayleton at 2lbs material/acre was used for powdery mildew control. Lorsban-4E was applied for insect control. The specific planting and harvest dates as well as plot size and design are shown on each test summary.

Tests are listed in the main table of contents for Salinas by types of material and evaluation. As an aid to find test summaries, they are listed below by ascending test (planting date) number and cross- referenced to the page number. Tests shown as N/A are not available or included in this report.

TEST NO.	NO. ENTRIES	TEST DESCRIPTION	PAGE NO.
YIELD TRIALS, BLOCK 4, PLANTED MARCH 1998			
1798	12	Evaluation of monogerm populations	A40
1898	48	Experimental hybrids	A44
1998	48	Population hybrids	A47
2098	24	Topcross hybrids	A50
ERWINIA ROOT ROT/POWDERY MILDEW EVAL., BLOCK 3, PLANTED MARCH 1998			
2198	125	Inheritance of Resistance to Powdery Mildew	n/a
2298	36	Evaluation of Powdery Mildew (Holly Hybrids)	n/a
2398	64	CBGA Coded Powdery Mildew	n/a
2498	160	ERR/PM Evaluation of Lines	A108
2598	100	ERR/PM Evaluation of Hybrids	A115
2698	12	Performance under Powdery Mildew	A34
YIELD TRIALS UNDER RHIZOMANIA, PLANTED MAY, 1998			
3198	36	Eval. of Lines with NR, *Rz*, *Bvm*, CR, PMR	A35
3298	48	Eval. PI's & Salinas lines	A37
3398	24	BTS Transgenic Trial	n/a
3498	29	Selection for Rhizomania Resistance	n/a
YIELD TRIALS UNDER RHIZOMANIA, PLANTED APRIL, 1998			
4198	8	Seedex line evaluation & selection	n/a
4298	12	Eval. of source populations	A33
4398	78	CBGA Coded Rhizomania	A64
4498	18	WS, BTS,USDA hybrid evaluation	A60
4598	48	Experimental hybrids	A54
4698	48	Population hybrids	A57
4798	48	Lines under rhizomania	A28
4898	24	Monogerm populations	A41
4998	128	S_1 progeny test MM, S^f, Aa, R22	n/a
5098	208	S_1 progeny test MM, S^f, Aa, *Rz*	n/a
5198	72	S_1 progeny test mm, S^f, Aa, *Rz*	n/a

TEST 1498. PERFORMANCE OF LINES WITHOUT VIRUS YELLOWS, SALINAS, CA., 1998

48 entries x 8 reps, RCB(E); 3 subtests: 16 x 8, RCB(E)
1-row plots, 21 ft. long

Planted: March 18, 1998
Harvested: October 5, 1998

Variety[3]	Description[3]	Acre Yield[1] Sugar Lbs	Acre Yield[1] Beets Tons	Sucrose %	Beets/ 100' No.	Root Rot %	RJAP %
1498-1: MM,O.P. Lines							
B4035R	Betaseed, 7-10-97	15317	44.18	17.34	142	0.0	87.9
KW6770	Betaseed, 6770.5193, 1-10-97	13485	37.69	17.89	130	0.0	91.3
97-US75	Inc. 268 (US75), susc.ck.	11292	36.74	15.05	139	0.0	88.9
97-C37	Inc. U86-37,(C37)	12133	35.53	17.09	143	0.0	86.7
R776-89-5NB	Inc. R576-89-5NB, C76-89-5	12657	36.16	17.51	137	0.0	86.8
R781	RZM-ER R581, C82	15135	46.17	16.39	131	0.0	86.8
R781-43	RZM-ER R581-43 (C31-43*Rz*)	14040	40.91	17.15	142	0.0	86.8
R776	RZM-ER R576 (C31*Rz*)	13475	39.27	17.14	137	0.0	88.4
Y768	RZM-ER Y568	15120	44.13	17.11	136	0.0	86.5
Y769(Iso)	RZM-ER Y569,(C69)	14968	42.18	17.74	134	0.0	86.1
R778(Iso)	RZM-ER R578,R578/2,R578%,(C78)	14617	41.65	17.54	131	0.0	86.9
R778%	RZM-ER-%S R578,R578/2,R578%	13899	39.70	17.52	135	0.4	86.7
R770	RZM-ER R570	14588	42.12	17.31	135	1.3	87.2
F_1MM,S^f,Aa,*Rz* sources of S_1's							
R776-89-5H11	5911-4mmaa x R576-89-5	15487	44.67	17.34	134	0.0	85.5
R776-89-5H13	6913-70aa x R576-89-5	14897	43.13	17.31	137	0.0	88.0
R776-89-5H31	6931aa x R576-89-5	16504	47.19	17.49	136	0.0	87.0
Mean		14225.8	41.34	17.18	136.2	0.11	87.3
LSD (.05)		1047.4	2.80	0.55	9.3	0.69	2.2
C.V. (%)		7.4	6.84	3.23	6.9	645.10	2.5
F value		13.1**	12.76**	11.29**	1.4NS	1.84*	3.1**

TEST 1498. PERFORMANCE OF LINES WITHOUT VIRUS YELLOWS, SALINAS, CA., 1998
48 entries x 8 reps, RCB(E). ANOVA to compare means across sets of entries.

Mean	13999.9	41.27	16.95	137.4	0.06	86.6
LSD (.05)	1026.3	2.85	0.55	10.1	0.49	2.3
C.V. (%)	7.4	7.00	3.32	7.4	808.30	2.7
F value	15.6**	14.49**	9.36**	1.9**	1.49*	3.5**

TEST 1498. PERFORMANCE OF LINES WITHOUT VIRUS YELLOWS, SALINAS, CA., 1998

(cont.)

Variety[3]	Description[3]	Acre Yield[1] Sugar Lbs	Acre Yield[1] Beets Tons	Sucrose %	Beets/ 100' No.	Root Rot %	RJAP %
1498-2: MM lines with WB germplasm							
Rizor	HH108, 9-3-97	15661	43.50	18.00	149	0.0	86.2
B4776R	Beta 4776R.7033, 9-1-97	16295	44.97	18.13	144	0.0	89.6
Y767	RZM-ER Y567, (C67)	14601	43.71	16.70	133	0.0	86.1
Y771	RZM Y671	14776	44.34	16.67	145	0.0	87.4
Y772	RZM Y672, (C72)	15221	46.03	16.58	131	0.0	86.6
Y773	RZM Y673R	13352	41.65	16.05	138	0.0	86.4
R779	RZM R679, C79-1(*Rz*)	12600	39.27	16.02	129	0.0	87.5
R735	RZM R635, C79-7 (SES)	12542	37.48	16.73	145	0.0	86.2
R736	RZM R636, C79-8 (R22)	13292	39.64	16.76	145	0.0	86.7
R746	RZM R646, BC_3F_4 (C37 X R22)	12267	36.85	16.65	142	0.0	89.1
R753	RZM R653, BC_4F_3 (C37 x R22)	11664	36.48	16.01	142	0.0	85.8
R740	RZM-ER R540%, R540-1, R551	12607	37.58	16.75	131	0.0	84.7
R780(Iso)	RZM-ER R580, R580NB,R580%	14109	41.60	16.95	139	0.0	85.0
R780/2	RZM-ER R580-#, (C80)	14124	39.27	17.98	139	0.0	87.0
R780-45	RZM-ER R580-45, (C80-45)	14173	40.67	17.42	134	0.0	86.4
R726 (C26)	RZM-ER R526, F_3 (C37 x *Bvm*-UK)	11512	34.58	16.65	141	0.0	84.8
Mean		13674.8	40.48	16.88	139.3	0.0	86.6
LSD (.05)		1046.8	2.82	0.56	9.4	---	2.5
C.V. (%)		7.7	7.03	3.33	6.8	---	2.9
F value		14.5**	11.42**	11.48**	3.1**	---	2.4**

TEST 1498. PERFORMANCE OF LINES WITHOUT VIRUS YELLOWS, SALINAS, CA., 1998

(cont.)

Variety[3]	Description[3]	Acre Yield[1] Sugar Lbs	Acre Yield[1] Beets Tons	Sucrose %	Beets/ 100' No.	Root Rot %	RJAP %
1498-3: MM,S^{f},Aa lines & populations							
Y769H31	6931aa x Y669	16321	47.83	17.06	131	0.0	87.0
7931	6931aa x 931(C)	15792	47.27	16.73	131	0.5	87.2
7924	6924,...aa x 924(C)	14449	43.60	16.60	133	0.0	84.4
7926	6931aa x 926(C)	15609	46.72	16.71	134	0.0	84.7
7923	RZM-ER 5922,5923	13345	39.12	17.05	144	0.4	86.0
7927	RZM-ER 5921H18	14472	43.76	16.54	139	0.0	85.3
7932CT	Inc. 6260-#-6263-#	12133	37.37	16.23	140	0.0	84.6
7911-4-10	RZM 6911-4-10 (Inc. S_1 lines)	10062	29.24	17.21	144	0.0	81.5
7918-21	RZM 6918-21 (Inc. S_1 lines)	12965	40.38	16.06	139	0.4	87.4
N724	Inc. N623,N624(galls)	12913	38.88	16.63	140	0.0	86.3
CR711	RZM R609,R610,...aa x CR11(C)	14355	43.29	16.58	137	0.0	84.8
CR712	6931aa x CR11(C),(CR09/10)	14983	43.92	17.06	130	0.0	86.3
Z725	Z625-#(C)aa x Z31(C),(CZ25)	14774	42.02	17.58	137	0.0	86.1
Z730	Z630-#(C)aa x Z31(C),(CZ25)	13657	39.33	17.35	137	0.0	85.9
Z731	6931aa x 731(C)	15873	46.45	17.11	139	0.0	87.8
7838	6828,...aa x 838(C),(mm popn)	13881	42.81	16.24	130	0.0	86.6
Mean		14099.0	42.00	16.80	136.7	0.08	85.7
LSD (.05)		1001.0	2.89	0.56	10.6	0.50	2.2
C.V. (%)		7.2	6.95	3.35	7.8	1129.01	2.6
F value		20.1**	20.47**	4.67**	1.5NS	0.88NS	3.8**

[1]See Test 1198 for VY inoculated, companion test. See Test 4798 for evaluation under rhizomania. There appeared to be no or very little rhizomania in Tests 1198-1698. Except for natural BWYV infection in noninoculation checks, little VY spread from the BYV-BWYV-BCYV inoculated tests.

[3]See Test 1198 for descriptions.

TEST 1198. PERFORMANCE OF LINES UNDER VIRUS YELLOWS INFECTION, SALINAS, CA., 1998

48 entries x 8 reps., RCB(E); 3 subtests, 16 entries x 8 reps., RCB(E)
1-row plots, 21 ft. long

Planted: March 17, 1998
Harvested: October 12, 1998
Inoc. BYV-BWYV-BCLV: May 13, 1998[1]

Variety[3]	Description[3]	Acre Yield[1] Sugar Lbs	Sugar %Loss	Beets Tons	Sucrose %	Beets/ 100' No.	RJAP %	Virus Yellows[2] Chronic Mean	Incipient Mean
1198-1: MM,O.P. Lines									
B4035R	Betaseed, 7-10-97	8144	47	25.72	15.82	148	85.7	6.3	5.8
KW6770	Betaseed, 6770.5193, 1-10-97	7096	47	21.43	16.56	146	85.6	7.0	5.9
97-US75	Inc. 268 (US75) susc. ck.	5261	53	18.95	13.90	145	83.7	7.1	5.1
97-C37	Inc. U86-37, (C37)	8411	31	26.39	15.91	149	86.9	5.2	3.2
R776-89-5NB	Inc. R576-89-5NB, C76-89-5	8637	32	26.63	16.23	136	83.6	4.3	3.9
R781	RZM-ER R581, C82	10869	28	34.31	15.84	145	85.2	5.3	4.2
R781-43	RZM-ER R581-43 (C31-43*Rz*)	10182	27	30.83	16.51	143	85.4	5.9	4.3
R776	RZM-ER R576 (C31*Rz*)	10384	23	32.68	15.91	141	85.7	4.7	4.0
Y768	RZM-ER Y568	10391	31	31.78	16.35	291	84.9	4.8	4.1
Y769(Iso)	RZM-ER Y569,(C69)	11077	26	33.04	16.76	142	84.4	4.9	4.7
R778(Iso)	RZM-ER R578,R578/2,R578%,(C78)	7840	46	24.39	16.10	134	84.6	5.6	4.6
R778%	RZM-ER-%S,R578/2,R578%	8047	42	24.94	16.14	137	84.9	5.8	4.6
R770	RZM-ER R570	10155	30	30.88	16.42	135	86.3	5.3	4.1
F_1MM,S^f-,Aa,*Rz* sources of S_1's									
R776-89-5H11	5911-4mmaa x R576-89-5	10952	29	33.41	16.39	142	83.8	4.7	4.3
R776-89-5H13	6913-70aa x R576-89-5	11522	23	35.53	16.23	142	84.8	4.7	4.3
R776-89-5H31	6931aa x R576-89-5	11496	30	35.63	16.14	139	84.7	4.4	4.7
Mean		9404.1	34	29.16	16.08	141.2	85.0	5.4	4.5
LSD (.05)		791.3	--	2.34	0.41	9.6	1.6	0.4	0.4
C.V. (%)		8.5	--	8.10	2.57	6.9	1.9	6.8	9.2
F value		41.1**	--	38.03**	19.29**	2.0*	2.5**	45.3**	21.8**

TEST 1198. PERFORMANCE OF LINES UNDER VIRUS YELLOWS INFECTION, SALINAS, CA., 1998
48 entries x 8 reps., RCB(E). ANOVA to compare means across sets of entries.

Mean	8914.8	36	27.90	15.95	139.7	84.9	5.6	4.5
LSD (.05)	745.6	--	2.25	0.43	10.1	1.8	0.4	0.4
C.V. (%)	8.5	--	8.18	2.73	7.4	2.1	6.6	9.8
F value	27.9**	--	24.76**	11.98**	1.8**	4.4**	27.7**	13.4**

TEST 1198. PERFORMANCE OF LINES UNDER VIRUS YELLOWS INFECTION, SALINAS, CA., 1998

(cont.)

Variety[3]	Description[3]	Acre Yield[1] Sugar Lbs	Sugar %Loss	Beets Tons	Sucrose %	Beets/ 100' No.	RJAP %	Virus Yellows[2] Chronic 08/03	Incipient Mean
1198-2: MM lines with WB germplasm									
Rizor	HH108, 9-3-97	7085	55	22.07	16.05	147	86.3	7.3	5.9
B4776R	Beta 4776R.7033, 9-1-97	8924	45	27.29	16.36	140	86.7	7.3	5.6
Y767	RZM-ER Y567,(C67)(R22Y)	10266	30	30.83	16.65	139	85.0	5.1	4.3
Y771	RZM Y671,(R22)	10099	32	31.41	16.06	148	87.1	5.2	4.4
Y772	RZM Y672,(C72)(R22)	9619	37	30.21	15.94	134	85.6	5.5	4.5
Y773	RZM Y673R,BC_5F_2(C37 x R22)	8768	34	28.77	15.26	140	85.6	6.0	4.1
R779	RZM R679, C79-1(*Rz*)	8001	37	26.43	15.16	140	85.3	5.3	4.1
R735	RZM R635, C79-7 (SES)	9162	27	28.61	16.01	144	83.6	5.9	4.3
R736	RZM R636, C79-8 (R22)	7455	44	24.86	14.99	143	82.5	5.8	4.7
R746	RZM R646, BC_3F_4 (C37 x R22)	8193	33	26.22	15.61	148	85.0	6.1	4.5
R753	RZM R653, BC_4F_3 (C37 x R22)	7729	34	24.65	15.69	137	86.7	5.9	4.6
R740	RZM-ER R540%, R540-1, R551	8740	31	27.34	15.99	143	84.8	6.0	4.1
R726 (C26)	RZM-ER R526, F_3 (C37 x *Bvm*-UK)	8317	28	27.11	15.34	142	81.5	5.2	4.9
MM,O.P. Lines									
R780(Iso)	RZM-ER R580,R580NB,R580%	9369	34	29.09	16.11	136	84.6	5.4	4.6
R780/2	RZM-ER R580-#, (C80)	9590	32	28.19	17.01	139	84.8	5.4	4.2
R780-45	RZM-ER R580-45, (C80-45)	8833	38	27.24	16.23	134	85.3	5.1	3.3
Mean		8759.4	36	27.52	15.90	141.0	85.0	5.8	4.5
LSD (.05)		581.2	--	1.74	0.44	9.8	1.7	0.4	0.5
C.V. (%)		6.7	--	6.40	2.77	7.0	2.1	7.0	10.4
F value		19.7**	--	14.97**	12.27**	1.5NS	5.9**	22.6**	13.0**

[1]See Test 1498 for noninoculated, companion test. %loss = [(SY NonVY - SY VY)/SY NonVY]100. %loss calculated from two separate tests, therefore losses between entries are relative.

[2]Virus yellows score based on a scale of 0 to 9 where 0 = normal green to 9 = 100% yellowed canopy. Mean score is for ratings on 6/11, 8/03, and 8/18/98.

[3]R776-89-5H11,H13,H31 and Y769H31 are F_1 hybrids between MM,S^f,aa plants and MM,S^sS^s,AA plants. These S^fAa lines will be used potentially as sources to produce S_1 progenies for evaluation for VYR,*Rz*,NB,%S, etc.

TEST 1198. PERFORMANCE OF LINES UNDER VIRUS YELLOWS INFECTION, SALINAS, CA., 1998

(cont.)

Variety[3]	Description[3]	Acre Yield[1] Sugar Lbs	Sugar %Loss	Beets Tons	Sucrose %	Beets/ 100' No.	RJAP %	Virus Yellows[2] Chronic 08/03	Incipient Mean
1198-3: MM,S^f,Aa lines & populations									
Y769H31	6931aa x Y669	10897	33	33.78	16.14	131	85.3	5.0	4.6
7931	6931aa x 931(C)	9902	37	31.93	15.51	130	83.0	5.2	4.4
7924	6924,…aa x 924(C)	9502	34	29.03	16.36	140	85.3	5.5	4.6
7926	6931aa x 926(C)	10009	36	31.51	15.88	137	84.7	5.2	4.8
7923	RZM-ER 5922,5923	7987	40	24.96	15.95	137	85.9	5.7	4.3
7927	RZM-ER 5921H18	8836	39	27.92	15.81	146	83.6	5.5	4.6
7932CT	Inc. 6260-#-6263-#	8567	29	27.17	15.75	136	83.9	5.5	4.1
7911-4-10	RZM 6911-4-10 (Inc. S_1 lines)	6352	37	19.43	16.33	142	80.3	5.7	3.9
7918-21	RZM 6918-21 (Inc. S_1 lines)	6103	53	20.57	14.84	136	85.3	5.6	3.4
N724	Inc. N623,N624(galls)	7558	41	24.55	15.41	136	84.3	6.0	4.3
CR711	RZM R609,R610,…aa x CR11(C)	7579	47	23.75	15.94	139	86.1	6.2	4.9
CR712	6931aa x CR11(C),(CR09/10)	9150	39	28.66	15.96	132	86.1	5.7	4.8
Z725	Z625-#(C)aa x Z31(C),(CZ25)	9271	37	28.61	16.21	141	84.4	5.9	5.0
Z730	Z630-#(C)aa x Z31(C),(CZ25)	7709	44	24.18	15.95	136	83.6	6.5	5.2
Z731	6931aa x Z31(C)	9475	40	29.16	16.25	131	85.9	5.8	4.7
7838	6828,…aa x 838(C),(mm popn)	8400	39	27.03	15.54	143	85.6	5.9	4.7
Mean		8580.9	39	27.02	14.86	137.0	84.6	5.7	4.5
LSD (.05)		759.4	--	2.29	0.45	9.5	2.0	0.3	0.4
C.V. (%)		8.9	--	8.58	2.89	7.0	2.4	5.5	9.6
F value		23.5**	--	23.16**	5.93**	1.8NS	4.5**	11.7**	8.1**

[3]7931 is base MM,S^f,*Rz*,A:aa population developed from C918. 7924 has germplasm from MM,O.P. lines. 7926,7923,7927 have genes from wild beet, particularly from R22(C51). N724 segregates for resistance to SBCN from B883. CR711 (CR09/10) has resistance to CLS from Italian germplasm. Z725 and Z730 (CZ25) have germplasm from high %S Polish accessions. 7838 is monogerm, S^f,A:aa population with CTR from C562,C546,C718,… and VYV from MM,O.P. lines.

TEST 4798. PERFORMANCE OF MULTIGERM LINES UNDER RHIZOMANIA, SALINAS, CA., 1998

48 entries x 8 replications, RCB(e); 3 subsets, 16 entries x 8 reps, RCB(e) Planted: April 28, 1998
1-row plots, 22 ft. long Harvested: October 21, 1998

Variety	Description	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Beets/ 100' No.	RJAP %	Powdery Mildew Score
4798-1: MM,O.P. lines							
B4035R	Betaseed, 7-10-97	12794	37.28	17.17	178	85.8	4.0
B4776R	Beta 4776R.7653 (3-27-98)	13405	37.39	17.92	208	86.6	2.3
Rizor	HH108, 9-3-97	12922	36.38	17.80	211	86.3	3.8
US H11	1997	8916	27.76	16.01	197	85.9	7.0
R776-89-5NB	Inc. R576-89-5NB, C76-89-5	9498	27.54	17.24	172	84.5	3.4
R781	RZM-ER R581, C82	12911	38.80	16.66	180	86.6	3.0
R781-43	RZM-ER R581-43	11207	32.91	17.02	170	85.7	5.1
R776	RZM-ER R576	10534	31.45	16.75	182	85.9	5.0
Y678	RZM-ER Y568	11186	32.91	16.99	184	85.1	4.0
Y769(Iso)	RZM-ER Y569, C69	12589	35.98	17.50	197	85.0	3.5
R778(Iso)	RZM-ER R578,R578/2,R578%(C78)	11886	34.43	17.26	181	86.2	3.9
R778%	RZM-ER-%S R578,R578/2,R578%(C78)	12467	35.68	17.46	195	84.7	3.6
R780(Iso)	RZM-ER R580,R580NB,R580%(C80)	12551	36.92	17.00	187	84.5	4.8
R780/2	RZM-ER R580-#(C80)	12464	35.36	17.61	186	85.6	4.6
R780-45	RZM-ER R580-45 (C80-45)	11956	34.84	17.16	178	86.2	3.5
R770	RZM-ER R570	11435	33.71	16.98	184	85.3	4.9
Mean		11795.1	34.33	17.16	186.8	85.6	4.1
LSD (.05)		1042.1	2.84	0.53	17.6	2.0	0.7
C.V. (%)		8.9	8.37	3.11	9.5	2.3	17.0
F value		11.7**	10.13**	6.11**	3.5**	1.0NS	19.3**

TEST 4798. PERFORMANCE OF MULTIGERM LINES UNDER RHIZOMANIA, 1998
48 entries x 8 replications, RCB(e). ANOVA to compare means across sets of entries.

Mean	11536.6	34.11	16.90	187.0	85.3	4.6
LSD (.05)	522.4	2.84	0.57	18.5	2.0	0.8
C.V. (%)	9.1	8.47	3.40	10.1	2.4	16.5
F value	13.5**	13.17**	6.23**	2.9**	2.3**	16.0**

TEST 4798. PERFORMANCE OF MULTIGERM LINES UNDER RHIZOMANIA, SALINAS, CA., 1998

(cont.)

Variety	Description	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Beets/ 100' No.	RJAP %	Powdery Mildew Score
4798-2: MM lines with WB germplasm							
Y765	RZM-ER Y565	12727	37.64	16.91	188	84.5	5.0
Y766	RZM-ER Y566	11472	32.80	17.48	198	87.1	4.4
Y767	RZM-ER Y567,C67	12437	36.03	17.26	203	86.8	3.6
Y771	RZM Y671	12369	36.78	16.83	197	84.2	5.1
Y772(Sp)	RZM Y672(C72) x Y74(C)	13161	39.15	16.79	178	86.5	4.4
Y773	RZM Y673R	10862	33.52	16.20	194	85.2	5.0
Y775	Y-Rrr(C) x Y74(C)	11436	33.96	16.84	180	84.9	4.1
R724/R725	RZM R824/R425,C79-2/3(WB41/42)	9552	28.34	16.86	189	83.8	6.3
R735	RZM R635, C79-7 (SES)	10404	30.59	17.00	199	85.3	5.5
97-C37	Inc. U86-37, C37	8924	27.01	16.52	200	85.0	6.6
R779	RZM R679, C79-1 (*Rz*)	9884	31.67	15.61	170	85.0	4.1
R736	RZM R636, C79-8 (R22)	10287	31.24	16.45	193	84.4	6.3
R746	RZM R646, BC_3F_4 (C37 x R22)	9871	30.03	16.45	202	84.1	6.1
R753	RZM R653, BC_4F_3 (C37 x R22)	10315	31.39	16.40	199	85.5	5.8
R740	RZM-ER R540%,R540-1,R551 (C79-#s)	10994	33.23	16.54	198	84.3	5.6
R726	RZM-ER R526, F_3 (C37 x *Bvm*-UK)	10269	30.52	16.84	197	83.1	6.0
Mean		10935.3	32.74	16.69	192.9	85.0	5.2
LSD (.05)		996.7	21.49	0.56	20.7	2.3	0.7
C.V. (%)		9.2	8.52	3.37	10.8	2.7	13.6
F value		12.0**	11.58**	4.80**	1.7NS	1.8*	13.1**

TEST 4798. PERFORMANCE OF MULTIGERM LINES UNDER RHIZOMANIA, SALINAS, CA., 1998

(cont.)

Variety	Description	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Beets/ 100' No.	RJAP %	Powdery Mildew Score
4798-3: MM,S^f,Aa lines and populations							
7926	6931aa x 926(C)	12899	38.37	16.80	179	85.0	3.8
7927	RZM-ER 5921H18	12188	35.72	17.06	183	85.2	3.9
7923	RZM-ER 5922,5923	11651	34.46	16.86	190	86.4	5.3
7747	Inc. 5747 (A,aa)	10206	33.00	15.49	208	85.0	6.6
7924	6924,…aa x 924(C)	12789	38.03	16.80	165	85.3	3.4
7931	6931aa x 931(C)	13480	40.31	16.74	172	84.8	4.0
7932CTM	Inc. 6260-# - 6263-#	10627	30.89	17.21	181	84.9	5.1
N724	Inc. N623,N624 (galls)	12213	34.72	17.60	184	87.0	4.4
7911-4-10	RZM 6911-4-10	7853	22.54	17.46	176	81.0	3.3
7918-21	RZM 6918-21	10897	34.01	16.00	189	87.0	3.0
Z725	Z625-#(C)aa x Z31(C), CZ25	12736	36.58	17.41	179	85.2	4.4
Z730	Z623-#(C)aa x Z31(C), CZ25	12098	35.88	16.85	180	85.7	4.6
Z731	6931aa x Z31(C)	13704	40.86	16.79	180	86.0	3.9
CR711	RZM R609,R610,…aa x CR11(C)	12400	36.38	17.04	186	85.3	4.9
CR712	6931aa x CR11(C)	12146	35.57	17.08	177	85.8	5.0
CR713	6260-6263aa x CR11(C)	12183	36.68	16.61	172	84.9	5.3
Mean		11879.4	35.25	16.86	181.2	85.3	4.4
LSD (.05)		1010.0	2.78	0.62	17.7	1.8	0.8
C.V. (%)		8.6	7.96	3.71	9.9	2.2	18.4
F value		15.8**	18.16**	5.67**	2.3*	4.3**	10.6**

TEST 1698. EVALUATION OF NON-INOCULATED SOURCE POPULATIONS, SALINAS, CA., 1998

12 entries x 8 reps., RCB[1]
1-row plots, 21 ft. long

Planted: March 18, 1998
Harvested: October 6, 1998

Variety[3]	Description[3]	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Beets/ 100' No.	Root Rot %	RJAP %
Checks							
Rizor	HH108, 9-3-97	15818	43.97	18.01	145	0.0	86.5
B4776R	Beta 4776R.7033, 9-1-97	15957	43.44	18.38	145	0.0	87.4
Sources of S_1 lines being evaluated in 1998							
R576-89-18H18	RZM 4918aa x R476-89-18	12853	37.45	17.16	127	0.0	85.7
R581H18	RZM 4918aa x RZM R481-43,-89	16310	47.51	17.15	147	0.0	87.9
7924	6924,…aa x 924(C)	14423	41.25	17.49	135	0.0	86.7
7931	6931aa x 931(C)	15368	44.39	17.31	141	0.0	87.0
Potential source lines to produce S_1's							
R776-89-5H31	6931aa x R576-89-5	15847	44.92	17.66	140	0.0	87.2
Y769H31	6931aa x Y669	15810	44.87	17.63	137	0.4	86.4
Z731H11	5911-4maa x Z31(C)	15042	42.97	17.51	136	0.4	86.0
7926H13	6913-70aa x 926(C)	14555	42.52	17.13	143	0.0	86.2
Y775	Y-Rrr(C) x Y74(C)	15017	42.52	17.65	130	0.0	85.7
CR713	6260-6263(C)aa x CR11(C)	14483	41.54	17.44	137	0.0	86.7
Mean		15123.6	43.11	17.54	138.6	0.07	86.6
LSD (.05)		1166.2	3.24	0.51	10.4	0.48	1.9
C.V. (%)		7.7	7.54	2.90	7.5	697.68	2.2
F value		5.3**	4.61**	4.18**	2.8**	0.90NS	1.0NS

[1]See Test 1398 for VY inoculated, companion test.

[3]4918 = C918. 7931 = base MM,S^f,*Rz*,Aa population derived from C918. Y775 = MM,S^sS^s line with resistance to rhizomania from R22(C51). CR713 combines germplasm with *Rz*, CTR, and CLS resistance. R476-89-18 = C76-89-18. R481-43 & -89 = C82.

TEST 1398. EVALUATION OF VIRUS YELLOWS INFECTED SOURCE POPULATIONS, SALINAS, CA., 1998

12 entries x 8 reps., RCB
1-row plots, 21 ft. long

Planted: March 17, 1998
Harvested: October 8, 1998
Inoc.BYV-BWYV-BCLV: May 13, 1998[1]

Variety[3]	Description[3]	Acre Yield[1] Sugar Lbs	Sugar %Loss	Beets Tons	Sucrose %	Beets/ 100' No.	RJAP %	Virus Yellows[2] Chronic Mean	Incipient Mean
Checks									
Rizor	HH108, 9-3-97	6937	56	21.43	16.18	146	86.6	7.0	6.3
B4776R	Beta 4776R.7033, 9-1-97	9540	40	28.82	16.55	150	87.8	6.8	5.3
Sources of S_1 lines being evaluated in 1998									
R576-89-18H18	RZM 4918aa x R476-89-18	9749	24	31.25	15.59	130	85.6	4.8	3.7
R581H18	RZM 4918aa x RZM R481-43,-89	11364	30	35.77	15.88	142	85.9	5.4	4.4
7924	6924,…aa x 924(C)	9771	32	30.67	15.94	142	85.1	5.6	4.9
7931	6931aa x 931(C)	9812	36	31.17	15.73	130	85.1	5.6	4.3
Potential source lines to produce S_1's									
R776-89-5H31	6931aa x R576-89-5	11594	27	35.74	16.24	131	86.3	4.7	4.4
Y769H31	6931aa x Y669	10815	32	33.41	16.19	135	85.4	5.5	4.7
Z731H11	5911-4maa x Z31(C)	9670	36	29.70	16.29	132	85.4	5.9	5.0
7926H13	6913-70aa x 926(C)	9885	32	31.41	15.73	146	84.1	5.3	4.5
Y775	Y-Rrr(C) x Y74(C)	9845	34	30.78	15.99	140	85.6	5.0	4.3
CR713	6260-6263(C)aa x CR11(C)	8345	42	26.76	15.59	134	85.1	6.0	4.7
Mean		9777.0	35	30.58	15.99	138.2	85.7	5.6	4.7
LSD (.05)		875.9	--	2.59	0.38	10.5	1.4	0.5	0.4
C.V. (%)		9.0	--	8.49	2.36	7.6	1.7	8.3	8.7
F value		16.1**	--	17.82**	5.18**	3.5**	3.4**	18.1**	19.8**

[1]See Test 1698 for noninoculated, companion test. %loss = [(SY NonVY - SY VY)/SY NonVY]100.

[2]Virus yellows score based on a scale of 0 to 9 where 0 = normal green to 9 = 100% yellowed canopy. Mean score is for ratings on 6/11, 8/03, and 8/26/98.

[3]These are source populations and F_1 hybrids that are being evaluated as potential sources of S_1 progenies for evaluation and selection for resistance to VY,Rz,NB,ERR,etc., and for % sucrose.

TEST 4298. RHIZOMANIA EVALUATION OF SOURCE POPULATIONS, SALINAS, CA., 1998

12 entries x 8 replications, RCB
1-row plots, 22 ft. long

Planted: April 29, 1998
Harvested: October 29, 1998

Variety	Description	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Beets/ 100' No.	RJAP %
Checks						
Rizor	HH108, 9-3-97	11410	32.05	17.81	192	86.2
B4776R	Beta 4776.7653 (3-27-98)	13172	36.83	17.89	191	87.8
Sources of S_1 lines being evaluated in 1998						
R576-89-18H18	RZM 4918aa x R476-89-18	8335	24.78	16.85	139	86.2
R581H18	RZM 4918aa x RZM R481-43,-89	11567	34.72	16.69	163	86.8
7924	6924,…aa x 924(C)	10568	31.10	17.02	152	86.0
7931	3961aa x 931(C)	10361	31.19	16.64	164	86.5
Potential source lines to produce S_1s in 1998						
R776-89-5H31	6931aa x R576-89-5	10469	30.20	17.33	158	86.5
Y769H31	6931aa x Y669	10772	31.84	16.92	161	86.7
Z731H11	5911-4maa x Z31(C)	10721	32.10	16.73	148	86.8
7926H13	6913-70aa x 926(C)	10996	32.60	16.86	173	86.0
R776-89-5H11	5911-4ma x R576-89-5	10135	29.66	17.08	172	86.0
R776-89-5H13	6913-70aa x R576-89-5	11199	32.63	17.19	175	85.3
Mean		10808.9	31.64	17.08	165.6	86.4
LSD (.05)		1005.4	2.99	0.37	17.4	1.6
C.V. (%)		9.3	9.50	2.18	10.6	1.8
F value		9.8**	7.43**	9.78**	6.7**	1.2NS

TEST 2698. PERFORMANCE UNDER POWDERY MILDEW, SALINAS, CA., 1998

12 entries x 8 reps, RCB
1-row plots, 21 ft. long

Planted: March 30, 1998
Not harvested for yield

Variety[1]	Description	Stand Count	Powdery Mildew						
		No.	07/31	08/07	08/13	08/20	08/26	09/03	Mean
US H11	F82-546H3 x C36	23	4.3	5.8	5.4	7.5	7.4	7.9	6.4
R746H8	F82-546H3 x RZM R646 (C79-8)	28	3.5	5.6	5.1	7.0	7.0	7.3	5.9
5KJ0142	Betaseed *Rz*-PMR, 8-18-97	18	1.4	3.0	3.1	5.4	5.9	6.9	4.3
B4776R	Betaseed 4776R.7033, 9-1-97	31	2.3	3.8	4.3	6.1	6.1	6.6	4.9
P601	PMR P401 (C37-WB97,242)	32	1.8	2.6	2.8	4.0	4.6	4.8	3.4
P604	PMR P404 (C37-WB242), (CP02)	32	1.5	2.5	2.1	3.4	4.1	4.9	3.1
R776-89-5	Inc. R576-89-5, C76-89-5	29	2.0	3.5	3.1	5.5	6.0	6.0	4.4
R539	NB-ER-RZM R139C7, C39R	28	1.4	2.6	3.0	4.6	5.1	5.9	3.8
Rizor	HH108, 9-3-97	25	2.6	4.6	5.1	7.1	7.0	7.9	5.7
SS-NB7R	173404 Spreckels, 3-3-98	22	2.9	4.8	4.1	6.5	6.4	7.1	5.3
R776-89-5H11	5911-4maa x R576-89-5	28	2.1	3.4	3.1	5.0	5.4	6.0	4.2
Y769H31	6931aa x Y669	26	1.8	2.6	2.4	4.0	5.1	5.4	3.5
Mean		26.7	2.3	3.7	3.6	5.5	5.8	6.4	4.6
LSD (.05)		3.5	0.5	0.5	0.6	0.6	0.5	0.7	0.4
C.V. (%)		13.2	23.0	14.6	15.5	11.2	8.8	11.2	8.0
F value		12.5**	23.1**	37.8**	32.0**	38.9**	30.6**	18.0**	67.6**

Under moderate rhizomania conditions. PM not controlled.

[1]P601 = F_2BC_3 (C37 * WB97, WB242) and segregates for resistance to PM. Individual plants would have managed from 0 to 9 for reaction to PM.

P604 = F_2BC_3 (C37 * WB242) and segregates for resistance to PM.

TEST 3198. OBSERVATION (SELECTION) OF LINES WITH NR,*Rz*,*Bvm* RESISTANCE,CR,CTR,PMR,…,
SALINAS, CA., 1998

36 entries x 4 reps, sequential
1-row plots, 11 ft. long

Planted: May 11, 1998
Harvested: November 18, 1998

Variety	Description	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Beets/ 100' No.	RJAP %	Powdery Mildew Score
Nematode, *Rz* resistance							
US H11	Susc. check	4707	15.92	14.65	205	85.7	7.0
N724	Inc. N623,N624(galls)	9920	30.02	16.55	191	85.2	5.3
N730	Inc. N629,N630(galls)	8172	23.58	17.50	186	84.4	4.5
N766M	Inc. N665,N666(galls)	9221	28.41	16.23	193	83.6	4.5
N766m	Inc. N665,N666(galls)mm	8558	26.19	16.33	180	84.6	4.5
N771,B(C)	6931aa x N499(WB)	5794	17.13	17.00	157	85.5	5.0
Powdery mildew resistance							
P601	PMR P401, F_2BC_3(C37 x WB97,242)	8787	25.99	16.90	195	83.1	3.0
P702NR-#(C)	P602NR⊗, composite, (WB242)	6612	19.55	16.85	184	83.1	4.5
P707,B	Y671 x P603, composite (WB97)	8574	24.99	17.20	182	84.7	4.5
P708,B	Y671 x P604, composite, (WB242)	8051	22.97	17.55	177	84.9	4.8
CR-*Rz*							
CR711	RZM R609,R610aa x CR11(C)	9200	26.60	17.35	189	86.8	5.3
CR710	CR-RZM R509-#,R510-#(C)	9742	28.61	17.02	177	85.7	5.0
CTR-*Rz*							
7932CT	Inc. 6260-# -- 6263-#	7652	22.17	17.25	168	84.9	5.3
***Rz* - Root aphid resistance**							
7933	Inc. 6264-#(C)	8529	25.39	16.77	189	84.5	4.5
VYR-*Rz* check							
R776-89-5	Inc. R576-89-5	7641	21.16	18.05	182	83.2	4.3

TEST 3198. OBSERVATION (SELECTION) OF LINES WITH NR,*Rz*,*Bvm* RESISTANCE,CR,CTR,PMR,...,
SALINAS, CA., 1998

(cont.)

Variety	Description	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Beets/ 100' No.	RJAP %	Powdery Mildew Score
R22 resistance							
97-C13	Inc. U86-37, susc.check	6184	19.14	16.20	198	85.4	7.3
Y773(Iso)	RZM Y673R	8047	24.78	16.25	193	85.0	6.3
Y765	RZM-ER Y565	10410	29.82	17.50	200	83.6	5.0
Y766	RZM-ER Y566	10275	29.02	17.70	195	84.6	4.0
Y769(Iso)	RZM-ER Y569, C69	9728	27.00	18.02	205	86.1	3.8
7934,B	RZM 6913-70aa x R636,composite	9383	27.30	17.17	184	84.2	6.0
Resistance from *Bvm*							
R726	RZM-ER R526, C26	7185	21.16	17.00	186	84.3	5.8
R727A	C37 x RZM *Bvm*-PI	6494	20.15	16.08	207	82.6	5.0
R727B	Y569rr x RZM *Bvm*-PI	9750	28.41	17.23	186	84.4	4.0
R720	RZM *B.v.maritima*-PI's	5163	16.77	15.25	130	79.5	4.8
R776-89-5NB	Inc. R576-89-5NB	7121	20.75	17.10	177	84.1	4.5
97-US 22/3	Inc. Y009 (=Inc. US22/3)	4998	15.11	16.48	184	86.7	7.5
97-SP22-0	Inc. SP7622-0	4343	13.90	15.65	184	85.9	5.8
7812M	RZM 6812, C890-2 (WB41)	5066	15.92	15.93	205	84.4	6.3
7818(Sp)	RZM 6818mmaa x 848(C), C890-8	8189	23.98	17.08	198	85.8	6.3
Monogerm lines							
7848	0790aa x 848(C)	7242	21.56	16.80	202	84.7	5.3
7808-#(C)	RZM 6808⊗, composite	6188	18.83	16.42	182	85.1	5.3
7864-14	Inc. 5864-14, C864-14	6010	17.13	17.55	155	87.1	5.3
7867-1	T-O 6867-1 (CTR), C867-1	6970	19.95	17.50	182	84.4	5.0
7869-6	T-O 6869-6	7330	21.46	17.15	195	83.5	5.8
6831-4	RZM,T-O sel. 4831-4mm, C831-4	7025	19.65	17.80	164	82.2	6.0
Mean		7618.4	22.51	16.86	185.1	84.6	5.2
LSD (.05)		1863.7	5.56	0.87	27.5	3.1	0.9
C.V. (%)		17.5	17.63	3.67	10.6	2.6	12.5
F value		6.4**	5.35**	5.93**	2.6**	1.7*	9.1**

Test under moderate rhizomania.

TEST 3298. EVALUATION OF PLANT INTRODUCTIONS, SALINAS, CA., 1998

48 entries x 4 replications, sequential
1-row plots, 11 ft. long

Planted: May 11, 1998
Not harvested for yield

Variety	Description	Stand Count	Harvest Count	RZM Resist	Powdery Mildew	End Use	Growth Habit	Bolt Tend	Root Color
		No.	No.	%	Score				
Checks									
US H11	rhizom. susc. check	21	20	19.2	7.0	5	1	2	1
R639	RZM R539 (resist. check)	20	21	82.1	4.3	5	1	2	1
97-SP22-0	Inc. SP7622-0 (VYS check)	21	23	32.8	6.5	5	1	2	1
R726	RZM-ER R526 (WB check)	22	22	76.2	6.0	5	1	2	1
Plant Introductions (Pullman)									
Beta vulgaris									
PI 142808	SD No. 7352	19	19	8.5	5.8	5	1	2	1,3,4
PI 142809	SD Choghondar	14	5	5.0	5.8	7	1	2	4
PI 142810	SD Choghondar	21	20	11.0	4.5	7	1	2	1
PI 142813	SD Choghondar	17	15	11.3	5.0	5	1	2	3,4
PI 169020	SD Pazi	16	14	8.9	5.8	7	1	3	4
PI 172730	SD No. 7425	16	13	25.4	5.5	3	1	3	1,3,4
PI 263865	SD	18	16	0.0	5.3	7	1	3	4
PI 264152	SD Irel	21	17	20.5	6.8	5	1	2	1
PI 269309	SD Good for all RIKS	20	18	8.5	6.3	2	1	2	4
PI 357354	SD Kocansko	20	16	7.8	5.5	7	1	3	4
PI 368376	SD Krusevska	21	19	10.9	6.0	5	4	2	1
PI 442069	SD	17	16	29.6	6.0	1	1	2	1
PI 486356	SD Pervomajskaja 028	20	21	13.5	6.5	5	1	2	1
PI 486360	SD MS-line 57?	22	22	21.5	6.5	5	1	2	1
PI 490993	SD WP 050	19	17	0.0	6.0	5	1	1	1
PI 491195	SD WP 121	16	18	3.9	5.0	7	1	3	1
PI 504173	SD Leaf beet	16	10	3.1	5.8	6	1	1	1

TEST 3298. EVALUATION OF PLANT INTRODUCTIONS, SALINAS, CA., 1998

(cont.)

Variety	Description	Stand Count	Harvest Count	RZM Resist	Powdery Mildew	End Use	Growth Habit	Bolt Tend	Root Color
		No.	No.	%	Score				
Beta vulgaris ssp. *vulgaris*									
NSL 80223	SD RS-3	20	17	6.8	6.0	6	1	1	1
NSL 81098	SD RS-1	18	16	4.6	4.8	7	1	3	1
NSL 93277	SD A76-36	19	19	4.0	5.8	7	1	3	1
NSL 93279	SD A76-38	20	19	9.0	5.5	7	1	3	1
NSL 95217	SD A77-46	19	19	8.6	5.8	7	1	3	1
Beta vulgaris ssp. *vulgaris*									
PI 386206	SD VNIS F-526	20	20	9.7	6.8	5	1	2	1
PI 386209	SD N 7776	20	20	14.9	5.8	5	1	2	1
PI 507849	SD 3700002	17	17	18.6	5.8	5	1	1	1
PI 535839	SD AJ-4	19	16	8.0	6.8	5	1	2	1
Beta vulgaris var. *cicla*									
PI 357359	SD Domasna	20	19	45.4	6.8	1	1	1	1
Beta vulgaris var. *maritima*									
PI 546378	SD WB 4	20	15	29.9	6.0	6	1	1	1
PI 546396	SD WB 146	16	15	7.9	5.5	6	1	1	1
PI 546422	SD WB 254	21	15	42.5	5.8	6	1	1	1
USDA entries (Multigerm lines)									
R727A	C37 x RZM *Bvm*-PI's	20	21	40.5	6.5				
R727B	Y569rr x RZM *Bvm*-PI's	22	25	50.1	4.8				
R728	RZM R328 (C79-4)	22	21	73.4	5.3				
Y775	Y-Rrr(C) x Y74(C)	22	21	70.7	5.0				
USDA entries (CLSR-*Rz*)									
R710	CR-RZM R509-#,R510-#(C)	18	18	84.1	5.5				
R709-1	CR-RZM R509A-1	21	22	76.0	4.8				
R709-9	CR-RZM R509A-9	20	18	82.4	6.0				
R710-10	CR-RZM R510A-10	16	15	72.4	4.8				
R710-14	CR-RZM R510A-14	13	12	70.6	7.0				

TEST 3298. EVALUATION OF PLANT INTRODUCTIONS, SALINAS, CA., 1998

(cont.)

Variety	Description	Stand Count	Harvest Count	RZM Resist	Powdery Mildew	End Use	Growth Habit	Bolt Tend	Root Color
		No.	No.	%	Score				
USDA entries (R22 monogerms)									
7818 Sp	RZM 6818mmaa x 848(C)	20	20	77.3	5.8				
7818-4	Inc. 6818B-4	23	21	57.4	4.5				
7818-14	T-O 6818B-14	21	21	66.8	5.3				
7818-22	Inc. 6818B-22	22	21	18.1	5.5				
7818-23	Inc. 6818B-23	23	20	13.9	6.3				
Mean		19.2	17.9	30.5	5.7				
LSD (.05)		3.0	3.9	16.4	0.9				
C.V. (%)		11.2	15.4	38.4	11.4				
F value		4.9**	6.9**	23.0**	4.5**				

NOTES:

END USE (Primary Use of Plant): 1 = chard; 2 = DDR-like; 3 = DDR,chard,spinach; 4 = fodder; 5 = sugar; 6 = wild beet type; 7 = mixed.

HABIT (general growth habit): 1 = erect; 2 = intermediate reading between 1 & 3; 3 = procumbent; 4 = intermediate reading between 3 & 5; 5 = prostrate (no more than 6" high).

BOLTING TENDENCY without cold induction: 1 = BB (annual) 100%; 2 = bb (biennial) 0%; 3 = B:bb(mixed) 1-99%.

ROOT COLOR (external color of root): 1 = white; 2 = yellow; 3 = orange; 4 = red.

RHIZOMANIA: 0 = immune; 1 = very resistant; 3 = resistant; 5 = intermediate; 7 = susceptible; 9 = highly susceptible.

POWDERY MILDEW: rated 0 to 9, where 9 = highly susceptible.

TEST 1798. EVALUATION OF MONOGERM POPULATIONS, SALINAS, CA., 1998

12 entries x 8 reps., RCB
1-row plots, 21 ft. long

Planted: March 18, 1998
Harvested: October 6, 1998

Variety	Description	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Beets/ 100' No.	RJAP %
Monogerm source populations						
7835	6833,...mmaa x 835(C), (T-O,CTR)	13201	38.90	16.98	144	86.3
7838	6828,...mmaa x 838(C), (mm x VYR)	13518	39.54	17.17	146	87.7
7869M	RZM-ER 5869 (A,aa), (867 x 890)	13833	41.28	16.75	143	87.6
7869NB	NB-RZM 5869 (A,aa), (867 x 890)	13049	37.85	17.25	139	86.9
7834NBM	NB-RZM 5834,5893(A,aa),(Rzmm x mm,T-O)	12390	36.77	16.89	134	86.1
7895M	NB-RZM 5895(A,aa),(867 x mm,T-O)	11501	34.52	16.65	142	85.0
7810NBM	NB-RZM 5810(A,aa),(C790 x sources)	11205	32.43	17.27	136	84.5
7848	0790mmaa x 848(C),(C790 x sources)	13052	40.83	15.98	142	86.8
7890	RZM-ER 5890(A,aa),(C890-1Rz)	11541	33.20	17.39	149	87.8
7817%	RZM-ER 5817(A,aa),(C890-7SES)	12587	36.00	17.49	133	85.0
7818%M	RZM-ER 5818(A,aa),(C890-8 R22)	11937	35.16	16.98	143	86.0
7818/2M	RZM 6818m(A,aa), (C890-8 R22)	12889	38.53	16.73	148	87.2
Mean		12558.6	37.09	16.96	141.5	86.4
LSD (.05)		1041.9	3.00	0.55	10.6	1.7
C.V. (%)		8.3	8.13	3.25	7.5	2.0
F value		5.3**	7.35**	4.45**	1.8NS	3.5**

TEST 4898. RHIZOMANIA EVALUATION OF MONOGERM POPULATIONS AND LINES, SALINAS, CA., 1998

24 entries x 8 replications, RCB(e)
1-row plots, 22 ft. long

Planted: April 29, 1998
Harvested: October 29, 1998

Variety	Description	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Beets/ 100' No.	RJAP %
Monogerm, *Rz* source populations						
R776-89-5NB	Inc.R576-89-5NB, C76-89-5	10071	29.28	17.20	162	84.2
7835	6833,...mmaa x 835(C), (T-O,CTR)	12254	36.18	16.94	180	85.2
7838	6828,...mmaa x 838(C),(mm x VYR)	11902	35.93	16.58	173	85.2
7869M	RZM-ER 5869(A,aa), (867 x 890)	12275	36.20	16.98	183	87.2
7869NB	NB-RZM 5869(A,aa),(867 x 890)	12089	35.17	17.19	179	85.6
7834NBM	NB-RZM 5834,5893(A,aa),(Rzmm x mm T-O)	11895	35.52	16.74	189	84.5
7895M	NB-RZM 5895(A,aa),(867 x mm T-O)	9605	29.58	16.24	191	85.7
7810NBM	NB-RZM 5810(A,aa),(C790 x sources)	10730	31.40	17.10	180	86.0
Sources of resistance in C790 background						
7848	0790mmaa x 848(C),(C790 x sources)	11701	35.47	16.45	169	85.6
7890	RZM-ER 5890(A,aa),(C890-1Rz)	10451	30.64	17.06	181	86.2
7812M	RZM 6812(A,aa),(C890-2/3,WB41/42)	11325	34.70	16.33	185	86.2
7814M	RZM 6814(A,aa),(C890-4,PI07)	12207	36.88	16.54	180	84.4
7815M	RZM 6815(A,aa),(C890-5,R04)	11099	34.21	16.23	189	85.7
7816M	RZM 6816(A,aa),(C890-6,R05)	11299	34.21	16.51	182	85.9
7817/2M	RZM 6817(A,aa),(C890-7,SES)	11617	34.83	16.69	192	84.3
7818/2M	RZM 6818(A,aa),(C890-8,R22)	11422	34.21	16.70	187	85.6
7819M	RZM 6819(A,aa),(C890-9,WB151)	11703	36.08	16.21	168	86.9
7820M	RZM 6820(A,aa),(C890-10,WB169)	11322	35.02	16.15	195	85.3
7821M	RZm 6821(A,aa),(C890-11,WB258)	11126	33.81	16.46	192	85.9
7817%M	RZM-ER-%S 5817,4277,4277P	11221	32.17	17.46	185	84.7
7817T-O	T-O 6817(A,aa),(C890-7,SES)	10552	31.77	16.61	167	86.6
7818%M	RZM-ER-%S 5818,(C890-8,R22)	11339	33.51	16.92	169	87.1
7818T-O	T-O 6818B-#,6818-#(C),(C890-8,R22)	9956	29.43	16.91	184	85.8
N766M	Inc. N665,N666 (galls)	11864	36.34	16.34	175	84.8
Mean		11292.8	33.86	16.69	180.7	85.6
LSD (.05)		856.5	2.34	0.49	16.1	1.9
C.V. (%)		7.7	7.03	2.97	9.1	2.3
F value		5.8**	7.89**	4.31**	2.4NS	1.5NS

TEST 1598. PERFORMANCE OF HYBRIDS WITHOUT VIRUS YELLOWS INOCULATION, SALINAS, CA., 1998

24 entries x 8 reps, RCB(E)
1-row plots, 21 ft. long

Planted: March 18, 1998
Harvested: October 7, 1998

Variety	Description	Acre Yield		Sucrose	Beets/ 100'	RJAP
		Sugar Lbs	Beets Tons	%	No.	%
Checks						
KW6770	Betaseed, 6770.5193, 1-10-97	13522	38.17	17.70	134	89.1
Rizor	HH108, 9-3-97	14989	42.18	17.77	146	86.7
B4776R	Beta 4776R.7033, 9-1-97	16964	46.35	18.30	142	88.0
B4035R	Betaseed, 7-10-97	14369	42.49	16.92	136	87.8
SS-NB7R	Spreckels, 3-3-98	14970	42.76	17.50	132	88.3
Experimental hybrids						
R776-89-5H27	6831-4HO x R576-89-5	15096	42.86	17.61	136	86.3
Y769H7	6911-4-7HO x Y669	15869	45.75	17.36	133	87.6
R778H7	6911-4-7HO x R678	15131	44.76	16.92	130	87.0
6913-70H50	C790-15CMS x 5913-70	15366	45.29	16.96	146	85.8
7918-21H50	C790-15CMS x RZM 6918-21	16066	48.72	16.49	145	88.5
7911-4-10H50	C790-15CMS x RZM 6911-4-10	14662	41.12	17.83	139	84.6
R776-89-5H50	C790-15CMS x R576-89-5	16273	46.56	17.49	130	87.8
R576-89-18H50	C790-15CMS x R476-89-18	16429	47.67	17.24	139	87.2
R778H50	C790-15CMS x R678	15253	43.44	17.55	133	87.9
Y774H50	C790-15CMS x Y74(C)	15144	44.24	17.14	140	88.4
7926H50	C790-15CMS x 926(C)	15263	44.87	17.04	137	89.9
7931H50	C790-15CMS x 931(C)	14979	43.87	17.06	136	87.8
7924H50	C790-15CMS x 924(C)	16041	46.51	17.24	137	88.0
Y769H50	C790-15CMS x Y669	15158	44.66	16.94	132	86.7
Y769H69	6869aa x Y669	15849	46.45	17.06	137	88.2

TEST 1598. PERFORMANCE OF HYBRIDS WITHOUT VIRUS YELLOWS INOCULATION, SALINAS, CA., 1998

(cont.)

Variety	Description	Acre Yield		Sucrose	Beets/ 100'	RJAP
		Sugar Lbs	Beets Tons	%	No.	%
Experimental hybrids (cont.)						
Z731H41	6831-4HO x Z31(C)	14891	43.02	17.33	131	86.3
R778H8	C546H3 x R678	13231	38.43	17.20	129	88.9
R778H34	6834%aa x R678	15039	42.97	17.49	134	87.1
R778H38M	6837aa x R678	14611	41.86	17.46	138	86.4
Mean		15215.2	43.96	17.32	136.5	87.5
LSD (.05)		1050.8	2.65	0.56	10.5	1.9
C.V. (%)		7.0	6.13	3.28	7.8	2.2
F value		5.0**	7.44**	3.63**	1.7NS	3.0**

NOTE: See Test 1298 for VY inoculated, companion test.

TEST 1898. EVALUATION OF EXPERIMENTAL HYBRIDS, SALINAS, CA., 1998

48 entries x 8 reps, RCB(E); 3 subtests: 16 x 8, RCB(E)
1-row plots, 21 ft. long

Planted: March 18, 1998
Harvested: September 29, 1998

Variety	Description	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Beets/ 100' No.	Root Rot %	RJAP %
1898-1: O.P. Pollinators							
US H11	L111102, 1997	12495	40.65	15.38	144	0.0	88.5
Rizor	HH108, 9-3-97	15517	44.45	17.48	146	0.8	86.2
B4776R	Beta 4776R large.7033, 9-1-97	16278	45.24	17.99	141	0.0	88.2
SS-NB7R	Spreckels, 3-3-98	14199	41.97	16.92	139	0.5	87.9
SS-NB5R	Spreckels, 3-3-98	14343	43.18	16.63	133	0.4	86.9
R779H50	C790-15CMS x RZM R679	14835	44.53	16.66	143	0.0	86.9
R735H50	C790-15CMS x RZM R635	14462	43.18	16.76	142	0.0	86.4
R778H8	C546H3 x R678	13669	41.35	16.55	129	0.0	87.0
R778H50	C790-15CMS x R678	15731	46.22	17.00	134	0.0	87.5
Y769H8	C546H3 x Y669	14189	44.13	16.08	140	0.0	87.9
Y769H50	C790-15CMS x Y669	15443	45.93	16.84	136	0.0	88.9
R776-89-5H8	C546H3 x R576-89-5	14908	43.55	17.10	142	0.0	88.3
R776-89-5H50	C790-15CMS x R576-89-5	15474	45.08	17.16	142	0.0	86.7
R776-89-5H27	6831-4HO x R576-89-5	15372	44.34	17.34	135	0.0	88.0
R678H33-5	5833-5aa x R578	14805	41.10	18.04	131	0.0	85.8
R680H50	C790-15CMS x RZM R580	15836	46.24	17.13	137	0.0	88.1
Mean		14847.1	43.82	16.94	138.4	0.1	87.5
LSD (.05)		1050.2	2.82	0.57	9.5	0.6	2.2
C.V. (%)		7.2	6.49	3.40	6.9	552.2	2.6
F value		6.4**	3.22**	10.32**	2.2NS	1.4NS	1.3NS

TEST 1898. EVALUATION OF EXPERIMENTAL HYBRIDS, SALINAS, CA., 1998
48 entries x 8 reps, RCB(E). ANOVA to compare means across sets of entries.

Mean	14980.8	44.33	16.90	139.9	0.04	87.3
LSD (.05)	1136.3	2.99	0.58	10.5	0.37	2.1
C.V. (%)	7.7	6.84	3.47	7.7	849.53	2.4
F value	6.1**	5.44**	8.02**	3.50**	1.37NS	2.4**

TEST 1898. EVALUATION OF EXPERIMENTAL HYBRIDS, SALINAS, CA., 1998

(cont.)

Variety	Description	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Beets/ 100' No.	Root Rot %	RJAP %
1898-2: Pollinators with rzm resistance from *Bvm*							
KW6770	Betaseed, 6770.5193, 1-10-97	13238	38.22	17.33	134	0.0	89.1
Rebecca	Betaseed 4KJ0158, 3-19-97	16643	48.62	17.13	150	0.0	89.7
B4035R	Betaseed, 7-10-97	14548	43.02	16.90	145	0.0	86.9
R522H52	C790-15H39 x RZM R522(C)	14239	43.02	16.55	137	0.0	84.8
R736H50	C790-15CMS x RZM R636	14786	43.92	16.83	137	0.0	86.4
R746H50(Sp)	C790-15CMS x RZM R646,R653	13820	42.07	16.40	140	0.0	87.9
R746H8	C546H3 x RZM R646,R653	12578	40.70	15.44	144	0.0	87.9
R746H50(Iso)	C790-15CMS x RZM R646	14100	42.28	16.67	141	0.0	87.7
R753H50	C790-15CMS x RZM R653	14372	43.94	16.38	135	0.0	88.4
Y771H50	C790-15CMS x RZM Y671	14012	42.18	16.60	130	0.0	86.6
Y772H50	C790-15CMS x RZM Y672	14789	42.92	17.24	138	0.0	87.5
Y773H50	C790-15CMS x RZM Y673R	14307	43.92	16.29	138	0.0	87.2
Y774H50	C790-15CMS x Y74(C)	14602	43.39	16.80	139	0.0	88.6
7926H50	C790-15CMS x 926(C)	14375	43.07	16.70	126	0.0	87.3
Z731H41	6831-4HO x Z31(C)	14266	42.21	16.91	116	0.0	84.5
7933H50	C790-15CMS x 6264(C)	14457	44.13	16.36	139	0.0	86.9
Mean		14320.8	42.98	16.66	136.9	0.0	87.3
LSD (.05)		1204.9	3.18	0.58	1.4	---	1.7
C.V. (%)		8.5	7.47	3.53	7.3	---	1.9
F value		3.8**	3.43**	4.72**	5.0**	---	5.5**

TEST 1898. EVALUATION OF EXPERIMENTAL HYBRIDS, SALINAS, CA., 1998

(cont.)

Variety	Description	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Beets/ 100' No.	Root Rot %	RJAP %
1898-3: S^f,MM,Aa pollinators and lines							
B4038R	Betaseed, L6KJ0190, 4-7-97	16689	45.66	18.28	146	0.0	87.5
HM7072	Hilleshog, 3.20-4.00, 2-24-98	15566	42.71	18.23	140	0.0	87.9
7931H50	C790-15CMS x 931(C)	15996	48.10	16.63	140	0.0	86.6
7924H50	C790-15CMS x 924(C)	14996	44.51	16.84	133	0.0	86.7
Z731H50	C790-15CMS x Z31(C)	15715	46.14	17.06	146	0.0	86.8
CR711H50	C790-15CMS x CR11(C)	15078	45.34	16.63	141	0.0	86.6
5911-4H50	C790-15CMS x RZM 4911-4	15239	44.97	16.96	141	0.0	85.8
6913-70H50	C790-15CMS x 5913-70	16109	47.46	16.98	146	0.0	87.6
6918-12H50	C790-15CMS x RZM 4918-12	15561	44.97	17.30	137	0.0	87.0
7918-21H50	C790-15CMS x RZM 6918-21	17166	51.42	16.70	153	0.0	89.8
7911-4-10H50	C790-15CMS x RZM 6911-4-10	15581	44.87	17.38	141	0.0	84.7
R710H50	C790-15CMS x CR-RZM R509,R510(C)	15667	45.08	17.38	145	0.0	87.6
R709-1H50	C790-15CMS x CR-RZM R509A-1	15809	44.97	17.58	145	0.0	86.3
R709-9H50	C790-15CMS x CR-RZM R509A-9	16681	51.78	16.09	149	0.4	88.5
R710-10H50	C790-15CMS x CR-RZM R510A-10	15717	46.29	16.98	154	0.0	86.7
R710-14H50	C790-15CMS x CR-RZM R510A-14	14823	45.03	16.46	153	0.0	87.0
Mean		15774.6	46.21	17.09	144.4	0.0	87.1
LSD (.05)		1130.6	2.80	0.58	9.9	---	2.2
C.V. (%)		7.2	6.13	3.44	6.9	---	2.6
F value		2.5**	5.89**	8.08**	2.8*	---	2.1*

TEST 1998. EVALUATION OF POPULATION HYBRIDS, SALINAS, CA., 1998

48 entries x 8 reps, RCB(E); 3 subtests: 16 x 8, RCB(E)
1-row plots, 21 ft. long

Planted: March 18, 1998
Harvested: September 29, 1998

Variety	Description	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Beets/ 100' No.	Root Rot %	RJAP %
1998-1: Topcross hybrids							
Rizor	HH108, 9-3-97	15963	44.24	18.06	147	0.4	86.8
B4776R	Beta 4776R.7033, 9-1-97	16852	46.66	18.06	152	0.0	87.2
Hybrids onto C790-15CMS							
R778H50	C790-15CMS x R678, C78	15817	46.14	17.14	137	0.0	86.6
Y769H50	C790-15CMS x Y669, C69	15642	46.24	16.92	149	0.0	86.5
R776-89-5H50	C790-15CMS x R576-89-5, C76-89-5	16033	45.60	17.59	137	0.0	87.1
Y774H50	C790-15CMS x Y74(C)(R22 resist)	15249	45.50	16.75	142	0.0	88.3
7931H50	C790-15CMS x 931(C)	15945	46.40	17.19	137	0.0	87.5
Z731H50	C790-15CMS x Z31(C)	15567	45.87	16.96	145	0.0	87.2
Hybrids onto C911-4-7							
R778H7	6911-4-7HO x R678	15215	44.60	17.05	134	0.0	85.6
Y769H7	6911-4-7HO x Y669	15254	45.40	16.80	136	0.0	84.9
R776-89-5H7	6911-4-7HO x R576-89-5	15400	44.66	17.26	138	0.0	85.1
Z731H7	6911-4-7HO x Z31(C)	15840	46.51	17.04	135	0.0	86.5
Retest of Topcrosses from 1997							
R678H33-5	(C833- 5)5833-5aa x R578	15517	42.65	18.24	140	0.0	86.2
R678H33-12	(C833-12)5833-12aa x R578	14929	44.20	16.88	121	0.0	86.2
R68OH29-3	(C829- 3)5829-3aa x R580	14638	42.18	17.35	127	0.0	85.3
R680H31-3	(C831- 3)5831-3aa x R580	15517	44.76	17.34	140	0.0	85.7
Mean		15586.1	45.10	17.29	138.5	0.03	86.4
LSD (.05)		1159.2	3.03	0.60	10.8	0.30	1.8
C.V. (%)		7.5	6.78	3.48	7.9	1128.61	2.1
F value		1.5NS	1.50NS	4.84**	4.1**	1.00NS	2.1*

TEST 1998. EVALUATION OF POPULATION HYBRIDS, SALINAS, CA., 1998
48 entries x 8 reps, RCB(E). ANOVA to compare means across sets of entries.

Mean	14732.8	42.92	17.17	138.0	0.03	86.3
LSD (.05)	1147.2	3.03	0.53	10.6	0.34	1.8
C.V. (%)	7.9	7.16	3.14	7.8	971.26	2.2
F value	4.0**	4.05**	4.51**	2.9**	0.93NS	2.0**

TEST 1998. EVALUATION OF POPULATION HYBRIDS, SALINAS, CA., 1998

(cont.)

Variety	Description	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Beets/ 100' No.	Root Rot %	RJAP %
1998-2: Population hybrids							
B4035R	Betaseed, 7-10-97	14405	41.44	17.36	151	0.4	87.3
Hybrids onto popn-769							
R778H69	6869aa x R678	14020	41.39	16.95	136	0.0	87.0
Y769H69	6869aa x Y669	15570	44.92	17.34	143	0.0	88.3
R776-89-5H69	6869aa x R576-89-5	14128	41.17	17.15	143	0.0	86.4
Y774H69	6869aa x Y74(C)	14052	41.91	16.77	138	0.0	87.0
7931H69	6869aa x 931(C)	15050	44.87	16.77	137	0.0	85.8
Z731H69	6869aa x Z31(C)	13855	41.12	16.84	133	0.0	88.0
CR711H69	6869aa x CR11(C)	14342	42.12	17.04	142	0.4	87.0
7924H69	6869aa x 924(C)	14454	42.81	16.89	134	0.0	85.8
7926H69	6869aa x 926(C)	14497	43.71	16.59	137	0.0	87.4
Populations x C78							
R778H28	6828aa x R678	13900	41.54	16.74	140	0.0	86.2
R778H33	6833aa x R678	14243	40.68	17.50	127	0.0	85.5
R778H33%	6833%aa x R678	13602	40.05	16.98	131	0.0	85.2
R778H34	6834%aa x R678	14529	41.70	17.43	140	0.0	85.5
R778H36	6836aa x R678	14174	40.96	17.31	133	0.0	85.0
R778H38M	6837aa x R678	14064	41.08	17.14	140	0.0	84.3
Mean		14305.3	41.97	17.05	137.9	0.05	86.4
LSD (.05)		1049.5	2.69	0.50	9.9	0.40	2.0
C.V. (%)		7.4	6.48	2.95	7.3	804.58	2.3
F value		1.7NS	2.18*	2.46*	2.5**	0.92NS	2.7**

TEST 1998. EVALUATION OF POPULATION HYBRIDS, SALINAS, CA., 1998

(cont.)

Variety	Description	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Beets/ 100' No.	Root Rot %	RJAP %
1998-3: Hybrids with progeny lines							
SS-NB7R	173404, 3-3-98	13592	39.96	17.01	140	0.0	86.4
Populations hybrids							
R778H12	(C890-2/3,WB41/42)6812maa x R678	13165	39.80	16.51	125	0.0	87.0
R778H17M	(C890-7,SES)6817maa x R678	13641	39.54	17.19	142	0.0	86.0
R778H18	(C890-8,R22)6818maa x R678	14887	42.28	17.61	146	0.0	85.3
R778H87	(C890-1,Rz)5890aa x R678	13204	39.80	16.60	131	0.0	87.4
Hybrids with progeny line selections							
R778H59-8	(C859- 8)6859-8aa x R678	14117	39.98	17.65	131	0.0	87.2
R778H93	(C891-10)6891-10HO x R678	14204	42.12	16.85	142	0.0	85.2
R778H64	(C864-14)5864-14HO x R678	14269	41.65	17.16	139	0.0	86.4
R778H31-4	(C831- 4)6831-4aa x R678	14272	40.61	17.56	130	0.0	85.3
Experimental hybrids							
Y769H39	91=762-17CMS x Y669	15172	46.40	16.35	141	0.0	86.7
R776-89-5H39	91-762-17CMS x R576-89-5	13947	40.77	17.09	139	0.0	85.7
R776-89-5H66	4867-1H50 x R576-89-5	14813	42.49	17.44	137	0.0	86.7
R776-89-5H13	6913-70aa x R576-89-5	14847	42.92	17.31	150	0.0	85.7
R776-89-5H27	6831-4HO x R576-89-5	14169	41.23	17.16	136	0.0	85.4
Z731H41	6831-4HO x Z31(C)	15474	43.13	17.92	136	0.0	86.9
7931H87	6890aa x 931(C)	15138	44.29	17.10	137	0.4	86.7
Mean		14306.9	41.69	17.16	137.6	0.03	86.3
LSD (.05)		1174.9	3.05	0.51	9.7	0.30	1.7
C.V. (%)		8.3	7.38	2.99	7.1	1128.61	2.0
F value		2.8**	3.02**	5.68**	3.3**	1.00NS	1.6NS

Test 2098. EVALUATION OF TOPCROSS HYBRIDS, SALINAS, CA., 1998

24 entries x 8 reps, RCB(E)
1-row plots, 21 ft. long

Planted: March 18, 1998
Harvested: October 1, 1998

Variety	Description		Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Beets/ 100' No.	RJAP %
Checks							
B4776R	Beta 4776R.7033, 9-1-97		16200	44.39	18.25	142	88.4
Rizor	HH108, 9-3-97		15669	43.66	17.94	142	86.6
Topcrosses with C76-89-5							
R776-89-5H50	C790-15CMS	x R576-89-5	15218	43.56	17.46	136	87.0
R776-89-5H27	6831-4HO (C831-4CMS)	x R576-89-5	15041	43.60	17.24	139	86.3
R776-89-5H10M	5911-4H50	x R576-89-5	14770	41.10	17.96	121	87.3
R776-89-5H11	5911-4maa	x R576-89-5	14286	41.12	17.38	130	86.1
R776-89-5H11-1	6911-4-1aa	x R576-89-5	14043	39.67	17.70	133	87.1
R776-89-5H11-15M	6911-4-15aa	x R576-89-5	13866	39.64	17.46	130	85.4
Topcrosses with C78							
R778H50	C790-15CMS	x R678	14926	42.76	17.45	142	87.1
R678H33-5	5833-5aa (C833-5)	x R678	15206	41.02	18.54	133	88.4
R778H17M	6817maa (C890-7,SES)	x R678	13618	39.38	17.29	142	86.3
R778H17-5	6817-5aa	x R678	13737	40.54	16.95	140	87.5
R778H17-6	6817-6aa	x R678	13620	39.15	17.40	111	88.5
R778H87	5890aa (C890-1Rz)	x R678	13797	40.66	16.96	130	86.7
R778H18	6818maa (C890-8,R22)	x R678	14875	42.39	17.52	134	86.2
R778H18-1	6818-1aa	x R678	12923	37.34	17.30	130	84.8
R778H18-2	6818-2aa	x R678	14165	40.46	17.51	135	85.4
R778H18-5	6818-5aa	x R678	13059	40.30	16.23	126	87.1
R778H18-6	6818-6aa	x R678	13205	37.80	17.45	129	86.3
R778H18-11	6816-11aa	x R678	12483	36.85	16.95	134	87.4

Test 2098. EVALUATION OF TOPCROSS HYBRIDS, SALINAS, CA., 1998

(cont.)

Variety	Description		Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Beets/ 100' No.	RJAP %
Topcrosses with C78 (cont.)							
R778H18-12	6818-12aa	x R678	13076	38.90	16.80	137	87.3
R778H18-21	6818-21aa	x R678	13676	38.86	17.60	128	86.2
R778H18B-1	6818B-1aa	x R678	14504	39.85	18.17	138	87.7
R778H18B-2	6818B-2aa	x R678	14383	40.54	17.76	145	86.9
Mean			14181.2	40.57	17.47	133.6	86.8
LSD (.05)			997.9	2.40	0.52	12.2	2.0
C.V. (%)			7.1	6.01	3.02	9.3	2.4
F value			6.8**	5.53**	7.26**	3.0**	1.7*

TEST 1298. PERFORMANCE OF HYBRIDS UNDER VIRUS YELLOWS INFECTION, SALINAS, CA., 1998

24 entries x 8 reps., RCB(E)
1-row plots, 21 ft. long

Planted: March 17, 1998
Harvested: October 7, 1998
Inoc. BYV-BWYV-BCLV: May 13, 1998

Variety[3]	Description[3]	Acre Yield[1]			Sucrose	Beets/ 100'	RJAP	Virus Yellows	
		Sugar	Sugar	Beets				Chronic	Incipient
		Lbs	%Loss	Tons	%	No.	%	Mean	Mean
Checks									
KW 6770	Betaseed, 6770.5193, 1-10-97	6555	52	19.53	16.77	141	88.6	7.3	5.6
Rizor	HH108, 9-3-97	6647	56	21.01	15.82	149	85.2	7.4	6.3
B4776R	Beta 4776R.7033, 9-1-97	8419	50	25.14	16.74	138	86.5	7.5	5.4
B4035R	Betaseed, 7-10-97	7610	47	23.65	16.10	146	85.2	6.0	5.1
SS-NB7R	Spreckels, 3-3-98	8242	45	25.34	16.24	140	85.9	6.0	5.4
Experimental Hybrids									
R776-89-5H27	6831-4HO x R576-89-5	10466	31	31.62	16.56	138	86.8	4.7	4.4
Y769H7	6911-4-7HO x Y669	10393	35	32.25	16.10	135	86.1	5.3	4.3
R778H7	6911-4-7HO x R678	9377	38	28.87	16.23	136	86.0	5.7	5.0
6913-70H50	C790-15CMS x 5913-70	9612	37	29.56	16.26	145	85.9	4.9	4.3
7918-21H50	C790-15CMS x RZM 6918-21	9249	42	28.40	16.27	149	86.9	5.4	3.7
7911-4-10H50	C790-15CMS x RZM 6911-4-10	7815	47	23.28	16.79	141	83.5	5.8	4.5
R776-89-5H50	C790-15CMS x R576-89-5	10777	34	31.97	16.85	143	87.6	4.7	4.4
R576-89-18H50	C790-15CMS x R476-89-18	10598	35	32.73	16.19	144	86.1	5.2	4.1
R778H50	C790-15CMS x R678	8809	42	26.92	16.36	139	86.0	6.0	4.7
Y774H50	C790-15CMS x Y74(C)	9170	39	28.53	16.06	139	86.5	5.5	4.1
7926H50	C790-15CMS x 926(C)	9037	41	28.40	15.93	136	86.2	5.5	4.5
7931H50	C790-15CMS x 931(C)	8810	41	27.66	15.93	139	86.5	5.8	4.6
7924H50	C790-15CMS x 924(C)	9308	42	28.56	16.30	142	86.8	5.3	4.4
Y769H50	C790-15CMS x Y669	9242	39	28.40	16.24	134	86.3	5.7	4.6
Y769H69	6869aa x Y669	8888	44	28.14	15.80	142	86.3	5.5	4.7

TEST 1298. PERFORMANCE OF HYBRIDS UNDER VIRUS YELLOWS INFECTION, SALINAS, CA., 19

(cont.)

Variety[3]	Description[3]	Acre Yield[1] Sugar Lbs	Sugar %Loss	Beets Tons	Sucrose %	Beets/ 100' No.	RJAP %	Virus Yellows Chronic Mean	Virus Yellows Incipient Mean
Experimental hybrids (cont.)									
Z731H41	6831-4HO x Z31(C)	8847	41	27.41	16.14	136	84.1	5.7	5.0
R778H8	C546H3 x R678	7426	44	23.23	15.99	130	85.4	6.5	5.4
R778H34	6834%aa x R678	7650	49	23.34	16.38	142	86.5	6.4	5.4
R778H38M	6837aa x R678	8540	42	26.18	16.30	143	85.9	5.7	4.4
Mean		8812.0	42	27.09	16.26	140.3	86.1	5.8	4.8
LSD (.05)		762.0	--	2.13	0.46	9.0	2.2	0.3	0.3
C.V.(%)		8.8	--	8.00	2.85	59.4	2.5	5.8	7.3
F value		17.5**	--	20.77**	3.31**	2.1**	1.7*	40.8**	24.2**

[1]See Test 1598 for noninoculated, companion test. %loss = [(SY NonVY - SY VY)/SY NonVY]100.

[2]Virus yellows score based on a scale of 0 to 9 where 0 = normal green to 9 = 100% yellowed canopy. Mean score is for ratings on 6/11, 8/03, and 8/18/98.

[3]See Test 1198 for description of pollinators. 5913-70 = C913-70. 6831-4 = C831-4. 6911-4-7 = C911-4-7. C546H3 = C562 x C546. 6869,6834, and 6837 = mm,S^f,Rz,Aa populations.

TEST 4598. RHIZOMANIA EVALUATION OF EXPERIMENTAL HYBRIDS, SALINAS, CA., 1998

48 entries x 8 reps., RCB(E); 3 subtests, 16 entries x 8 reps., RCB(E)
1-row plots, 22 ft. long

Planted: April 28, 1998
Harvested: October 19, 1998

Variety	Description	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Beets/ 100' No.	RJAP %
4598-1: Resistance from C51(R22)*Bvm*						
B4035R	Betaseed, 7-10-97	10739	31.64	16.98	188	87.7
Rizor	HH108, 9-3-97	11422	32.35	17.65	210	85.9
SS-NB7R	Spreckels, 173404 (3-3-98)	9612	28.92	16.65	179	87.2
B4776R	Beta 4776R.7653 (3-27-98)	12209	34.11	17.90	198	87.8
US H11	L113101, 1997	6040	20.10	14.98	198	86.7
R746H8	C546H3 x RZM R646,R653	8534	25.65	16.64	192	87.4
R746H50(Sp)	C790-15CMS x RZM R646,R653	9400	28.22	16.68	191	86.2
R746H50	C790-15CMS x RZM R646	10279	30.23	16.96	193	87.1
R779H50	C790-15CMS x RZM R679, C79-1*Rz*	9607	29.33	16.40	187	86.9
R736H50	C790-15CMS x RZM R636, C79-8R22	10570	31.90	16.57	199	85.6
R753H50	C790-15CMS x RZM R653	8691	26.20	16.58	193	86.5
Y773H50	C790-15CMS x RZM Y673R	9098	28.02	16.26	193	85.4
Y772H50	C790-15CMS x RZM Y672, C72	10149	29.63	17.11	194	85.4
Y774H50	C790-15CMS x Y74(C)	9288	28.77	16.17	191	84.7
7926H50	C790-15CMS x 926(C)	9430	28.73	16.40	192	85.1
R735H50	C790-15CMS x RZM R635, C79-7SES	9177	27.39	16.75	203	86.4
Mean		9640.3	28.82	16.67	193.9	86.4
LSD (.05)		1012.4	2.75	0.54	17.0	1.8
C.V. (%)		10.6	9.62	3.27	8.9	2.2
F value		14.5**	10.87**	11.33**	1.3NS	2.1*

TEST 4598. RHIZOMANIA EVALUATION OF EXPERIMENTAL HYBRIDS, 1998.
48 entries x 8 reps., RCB(E). ANOVA to compare means across sets of entries.

Mean	10019.2	29.79	16.81	190.7	86.6
LSD (.05)	969.6	2.75	0.47	18.0	1.7
C.V. (%)	9.8	9.37	2.85	9.6	2.0
F value	12.7**	10.74**	15.24**	2.9**	2.5**

TEST 4598. RHIZOMANIA EVALUATION OF EXPERIMENTAL HYBRIDS, SALINAS, CA., 1998

(cont.)

Variety	Description	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Beets/ 100' No.	RJAP %
4598-2: Resistance from Rz,MM,O.P. Pollinators						
HM7072	Hilleshog, 3.20-4.00 (2-24-98)	10916	29.12	18.73	168	87.0
B4038R	Betaseed, L6KJ0190 (4-7-97)	12180	33.05	18.42	200	87.3
KW6770	Betaseed, 6770.5193 (1-10-97)	7448	21.87	17.06	181	88.1
R678H33-5	5833-5aa (C833-5)x R578	11354	32.05	17.74	192	86.6
R680-H29-3	5829-3aa (C829-3) x R580	10112	29.28	17.30	170	84.9
R680H31-3	5831-3aa (C831-3) x R580	10813	31.47	17.17	179	87.2
R776-89-5H8	C546H3 x (C562CMS x C54) R576-89-5	8785	25.50	17.20	192	86.2
R776-89-5H50	C790-15CMS x R576-89-5	10594	30.13	17.59	179	88.6
R776-89-5H27	6831-4HO (C831-4CMS) x R576-89-5	10148	29.22	17.38	179	85.7
R576-89-18H50	C790-15CMS x R476-89-18	9610	28.62	16.79	198	86.6
R778H8	C546H3 (C562CMS x C546) x R678	9305	27.86	16.69	191	88.3
R778H50	C790-15CMS x R678	9542	28.42	16.84	181	85.8
R778H7	6911-4-7HO (C911-4-7CMS) x R678	10010	29.83	16.81	178	86.5
Y679H8	C546H3 x Y669	8333	25.95	16.10	183	86.9
Y769H50	C790-15CMS x Y669	9308	28.62	16.30	191	86.5
Y769H7	6911-4-7HO (C911-4-7CMS) x Y669	10026	30.18	16.63	179	86.1
Mean		9905.3	28.82	17.17	183.8	86.8
LSD (.05)		1030.7	2.89	0.43	18.8	3.1
C.V. (%)		10.5	10.14	2.53	10.3	2.1
F value		10.1**	6.81**	20.88**	1.9*	2.5**

TEST 4598. RHIZOMANIA EVALUATION OF EXPERIMENTAL HYBRIDS, SALINAS, CA., 1998

(cont.)

Variety	Description	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Beets/ 100' No.	RJAP %
4598-3: Resistance from *Rz*,MM,S^f,Aa Pollinators						
SS-NB5R	Spreckels SS-IV2R.522401 (3-3-98)	8888	27.01	16.48	165	86.9
Rebecca	Betaseed 4KJ0158 (3-19-97)	12181	35.26	17.27	200	87.3
6913-70H50	C790-15CMS x 5913-70	10940	32.75	16.73	207	86.8
7911-4-10H50	C790-15CMS x RZM 6911-4-10	11140	31.98	17.41	194	85.0
6918-12H50	C790-15CMS x RZM 4918-12	10251	30.69	16.70	201	86.3
7918-21H50	C790-15CMS x RZM 6918-21	11489	36.13	15.91	212	87.5
7931H50	C790-15CMS x 931(C)	9744	29.33	16.65	190	88.1
7924H50	C790-15CMS x 924(C)	10003	29.68	16.85	187	88.3
Z731H50	C790-15CMS x Z31(C)	10504	31.91	16.46	193	86.0
CR711H50	C790-15CMS x CR11(C)	9787	30.23	16.19	188	85.3
R710H50	C790-15CMS x CR-RZM R509,10(C)	10377	31.12	16.69	182	86.7
R709-1H50	C790-15CMS x CR-RZM R509A-1	12048	35.07	17.17	191	86.2
R709-9H50	C790-15CMS x CR-RZM R509A-9	11346	35.72	15.90	205	87.3
R710-10H50	C790-15CMS x CR-RZM R510A-10	11054	34.26	16.15	211	85.8
R710-14H50	C790-15CMS x CR-RZM R510A-14	8232	26.10	15.80	209	88.1
Z731H7	6911-4-7HO x Z31(C)	10209	30.23	16.89	179	86.5
Mean		10512.1	31.72	16.58	194.5	86.8
LSD (.05)		805.8	2.36	0.42	18.0	1.4
C.V. (%)		7.7	7.51	2.58	9.4	1.7
F value		13.7**	12.82**	10.62**	4.0**	3.6**

TEST 4698. RHIZOMANIA EVALUATION OF POPULATION HYBRIDS, 1998

48 entries x 8 reps., RCB(E); 3 subtests, 16 entries x 8 reps., RCB(E)
1-row plots, 22 ft. long

Planted: April 28, 1998
Harvested: October 20, 1998

Variety	Description	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Beets/ 100' No.	RJAP %
4698-1: Checks and Popn-869 as tester						
US H11	L111101, 1997	8182	26.25	15.59	200	87.9
B4035R	Betaseed, 7-10-97	11481	33.15	17.30	195	85.3
SS-NB7R	Spreckels, 173404 (3-3-98)	10946	31.79	17.23	180	86.3
Rizor	HH108, 9-3-97	12141	34.01	17.85	193	85.7
R778H50	C790-15CMS x R678	12396	35.27	17.56	193	86.5
R776-89-5H50	C790-15CMS x R576-89-5	11519	32.90	17.51	191	86.5
R778H69	6869aa x R678, C78	11836	34.39	17.23	197	87.4
Y769H69	6869aa x Y669, C69	12401	35.93	17.27	195	87.7
R776-89-5H69	6869aa x R576-89-5, C76-89-5	11224	32.50	17.27	200	85.2
Y774H69	6869aa x Y74(C)	11608	34.11	17.05	189	85.7
7931H69	6869aa x 931(C)	11531	33.86	17.02	187	86.4
Z731H69	6869aa x Z31(C)	11516	34.26	16.83	194	86.7
CR711H69	6869aa x CR11(C)	11848	35.02	16.92	189	86.4
7924H69	6869aa x 927(C)	11663	34.47	16.94	182	87.1
7926H69	6869aa x 926(C)	11688	34.57	16.90	191	86.9
R776-89-5H7	6911-4-7HO x R576-89-5	11694	33.46	17.49	187	87.1
Mean		11479.6	33.50	17.12	191.4	86.5
LSD (.05)		905.5	2.91	0.56	16.3	2.0
C.V. (%)		8.0	7.24	3.30	8.6	2.3
F value		8.8**	6.57**	6.16**	1.0NS	1.3NS

TEST 4698. RHIZOMANIA EVALUATION OF POPULATION HYBRIDS, 1998
48 entries x 8 reps., RCB(E). ANOVA to compare means across sets.

Mean		11578.5	33.43	17.31	189.0	86.0
LSD (.05)		875.7	2.44	0.50	17.2	1.7
C.V. (%)		7.7	7.40	2.92	9.2	2.0
F value		7.7**	6.14**	5.27**	4.0**	1.8**

TEST 4698. RHIZOMANIA EVALUATION OF POPULATION HYBRIDS, 1998

(cont.)

Variety	Description	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Beets/ 100' No.	RJAP %
4698-2: Population Hybrids						
B4776R	Beta 4776R.7653 (3-27-98)	13952	38.60	18.09	213	87.3
R778H28	6828aa x R678	10573	31.34	16.88	190	84.2
R778H33	6833aa x R678	12005	33.84	17.74	175	85.9
R778H33%	6833%aa x R678	12482	35.37	17.64	179	85.3
R778H34	6834%aa x R678	12050	34.32	17.56	201	86.0
R778H36	6836aa x R678	11413	32.67	17.50	175	85.7
R778H38M	6837aa x R678	11938	34.21	17.44	205	85.0
R778H59-8M	6859-8aa (C859-8) x R678	10391	28.97	17.96	190	85.3
R778H93	6891-10HO (C891-10) x R678	12080	35.37	17.08	202	86.2
R778H64	5864-14HO (C864-14) x R678	11656	33.62	17.31	191	85.5
7931H87	6890aa (C890-1) x 931(C)	11851	34.77	17.02	194	86.1
R776-89-5H66	4867-1H50 (C867-1H50) x R576-89-5	10671	30.33	17.59	198	85.4
R776-89-5H13	6913-70aa x R576-89-5	11461	33.46	17.14	198	85.9
R776-89-5H31	6931aa x R576-89-5	11786	33.71	17.49	182	85.6
R776-89-5H27	6831-4HO x R576-89-5	11496	32.60	17.64	186	85.7
R776-89-5H11	5911-4aa x R576-89-5	10888	31.04	17.54	178	85.5
Mean		11668.2	33.39	17.48	191.0	85.7
LSD (.05)		890.7	2.43	0.48	16.1	1.5
C.V. (%)		7.7	7.34	2.76	8.5	1.8
F value		7.3**	6.97**	3.71**	4.0**	1.5NS

TEST 4698. RHIZOMANIA EVALUATION OF POPULATION HYBRIDS, 1998

(cont.)

Variety	Description	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Beets/ 100' No.	RJAP %
4698-3: Topcross Hybrids						
Rebecca	Betaseed 4KJ0158 (3-19-97)	14043	39.00	18.01	203	87.2
R778H87	5890aa (C890-1Rz) x R678	10884	31.90	17.05	175	86.2
R778H12M	6812aa (C890-1/2,WB41/42) x R678	11539	33.46	17.26	204	86.8
R778H17M	6817aa (C890-7SES) x R678	12029	35.27	17.09	188	85.4
R778H17-5	6817-5aa x R678	11562	33.71	17.15	191	85.8
R778H17-6	6817-6aa x R678	11568	33.38	17.33	142	86.8
R778H18	6818aa (C890-8R22) x R678	11920	35.17	16.98	189	85.9
R778H18B-1	6818B-1aa x R678	11940	33.56	17.80	194	86.1
R778H18B-2	6818B-2aa x R678	11501	32.55	17.67	201	85.2
R778H18B-21	6818B-21aa x R678	11564	32.86	17.60	181	85.3
R778H18-1	6818-1aa x R678	11137	31.49	17.70	186	84.0
R778H18-2	6818-2aa x R678	12292	35.45	17.36	189	85.0
R778H18-6	6818-6aa x R678	10760	31.04	17.34	192	85.4
R778H18-11	6818-11aa x R678	10762	31.95	16.88	172	85.2
R778H18-12	6818-12aa x R678	10230	29.88	17.11	190	86.2
R778H18-21	6818-21aa x R678	11672	34.01	17.16	156	86.2
Mean		11587.7	33.42	17.34	184.5	85.8
LSD (.05)		834.2	2.36	0.42	19.1	1.6
C.V. (%)		7.3	7.13	2.42	10.5	1.9
F value		8.2**	6.55**	4.84**	5.9**	2.0*

TEST 4498. WESTERN SUGAR, BETASEED, & USDA HYBRID EVALUATION UNDER RHIZOMANIA, SALINAS, CA., 1998

18 entries x 8 replications, RCB
1-row plots, 22 ft. long

Planted: April 28, 1998
Harvested: (Rep. 1-4) October 26, 1998
(Rep. 5-8) November 03, 1998

Variety	Description	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Beets/ 100' No.	RJAP %	Resistance DI	Resistance %R(0-3)	Resistance %R(0-4)
Western Sugar entries									
Beta A827R	Betaseed, 4-24-98	11901	32.25	18.41	179	84.8	3.4	63.9	87.9
HH-Rizor	Holly, 4-24-98	12743	35.88	17.76	197	85.2	3.2	74.0	94.2
Monohikari	Seedex, 4-24-98	8893	26.82	16.41	196	89.0	5.3	15.8	20.2
HM 1639	Novartis, 4-24-98	11704	33.02	17.73	201	87.1	2.4	94.8	97.7
Beta 826R	Betaseed, 4-24-98	12592	34.61	18.09	207	87.6	3.1	75.7	92.0
Beta 7CG9236LL	Betaseed transgenic	12259	31.42	19.51	204	86.3	2.8	88.7	99.5
Checks									
B4776R	Betaseed 4776.7653(3-27-98)	12967	36.67	17.69	195	86.8	2.3	93.0	98.7
B4038R	Betaseed, 16KJ090 (4-7-97)	13757	36.97	18.61	196	87.1	3.0	74.2	86.0
KW6770	Betassed, 6770.5193(1-10-97)	9476	26.70	17.58	193	87.0	5.0	17.4	30.8
Betaseed entries									
4CG6202	Betaseed, 3-23-98	10474	29.49	17.72	188	85.8	3.4	63.1	89.4
5KJ5017	Betaseed, 3-23-98	13349	36.55	18.27	194	87.5	2.6	90.4	99.4
6CG7229	Betaseed, 3-23-98	10331	28.23	18.29	158	85.9	3.6	49.0	81.4
6CG7265	Betaseed, 3-23-98	12159	35.53	17.06	204	86.5	3.2	66.7	87.6
7CG7084	Betaseed, 3-23-98	10799	30.88	17.54	164	85.8	3.4	56.7	78.6
7CG7328	Betaseed, 3-23-98	9137	24.74	18.50	141	85.8	3.7	45.0	82.0
Checks									
B4035R	Betaseed, 7-10-97	11256	32.80	17.15	180	86.6	3.0	77.9	90.5
R776-89-5H7	6911-4-7HO x R576-89-5	11617	33.36	17.41	194	85.6	3.2	68.8	87.6
US H11	L113102, 1997	7084	22.76	15.25	191	86.7	5.2	10.1	24.6
Mean		11250.0	31.59	17.72	187.8	86.5	3.4	62.5	79.4
LSD (.05)		1091.2	3.02	0.53	16.5	1.4	0.5	12.3	11.0
C.V. (%)		9.8	9.65	3.04	8.9	1.7	9.4	13.9	9.8
F value		20.3**	16.08**	23.58**	8.9**	3.8**	29.7**	36.5**	44.0**

TEST 4498. WESTERN SUGAR, BETASEED, & USDA HYBRID EVALUATION UNDER RHIZOMANIA, SALINAS, CA., 1998

(cont.)

Variety	Description	Acre Yield		Sucrose	Beets/ 100'	RJAP	Resistance		
		Sugar	Beets						
		Lbs	Tons	%	No.	%	DI	%R(0-3)	%R(0-4)

NOTES: Test 4498 was planted into two 18 variety x 4 replication sections, 4398-1 and 4398-2. Test 4398 was analyzed and summarized three ways: 4498(18V x 8R,RCB); 4498-1(18V x 4R, RCB); and 4498-2(18V x 4R,RCB). 4498-1 was in an area of the field that had uniform and moderate levels of rhizomania. 4498-2 was in an area nearby, but had light to mild rhizomania. After visual inspection, test 4498-1 was chosen for hand harvest and scoring individual plants for rhizomania. 4498-2 was machine harvested and was not scored for rhizomania.

Rhizomania was scored on a scale of 0 to 9 where 9 = severe. Because rhizomania was moderate, root symptoms formed a continuum and it was not completely obvious where to draw the line between resistance and susceptibility. Disease reaction for US H11 suggested that classes 0-3 were resistant and 4-9 susceptible. However, resistant varieties suggested that 0-4 was resistant and 5-9 susceptible with regards to the *Rz* gene. In table 4498-1, analyses were run both ways. Probably, where 0-3 = resistant, the frequency of resistant plants was underestimated; where 0-4 = resistant, the frequency of resistant plants was overestimated. DI = disease index is the weighted mean of the ratings for each variety where a lower value suggests higher resistance.

TEST 4498-1. WESTERN SUGAR, BETASEED, & USDA HYBRID EVALUATION UNDER RHIZOMANIA, SALINAS, CA., 1998

18 entries x 4 replications, RCB
1-row plots, 22 ft. long

Planted: April 28, 1998
Harvested: November 03, 1998

Variety	Description	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Beets/ 100' No.	RJAP %	Resistance DI	Resistance %R(0-4)	Resistance %R(0-3)
Western Sugar entries									
Beta A827R	Betaseed, 4-24-98	9901	27.31	18.13	174	84.4	3.4	63.9	87.9
HH-Rizor	Holly, 4-24-98	11133	31.55	17.65	190	84.9	3.2	74.0	94.2
Monohikari	Seedex, 4-24-98	5958	18.88	15.80	193	88.6	5.3	15.8	20.2
HM 1639	Novartis, 4-24-98	9654	27.15	17.76	200	88.0	2.4	94.8	97.7
Beta 826R	Betaseed, 4-24-98	10237	29.22	17.49	196	87.2	3.1	75.7	92.0
Beta 7CG9236LL	Betaseed transgenic	9853	25.40	19.41	201	86.3	2.8	88.7	99.5
Checks									
B4776R	Betaseed 4776.7653(3-27-98)	11787	33.64	17.54	192	86.5	2.3	93.0	98.7
B4038R	Betaseed, 16KJ090 (4-7-97)	11399	30.81	18.52	185	87.1	3.0	74.2	86.0
KW6770	Betassed, 6770.5193(1-10-97)	6408	18.94	16.94	180	86.3	5.0	17.4	30.8
Betaseed entries									
4CG6202	Betaseed, 3-23-98	8770	25.03	17.51	181	85.6	3.4	63.1	89.4
5KJ5017	Betaseed, 3-23-98	11332	31.18	18.21	190	87.2	2.6	90.4	99.4
6CG7229	Betaseed, 3-23-98	8326	22.89	18.23	137	86.3	3.6	49.0	81.4
6CG7265	Betaseed, 3-23-98	10512	31.76	16.56	204	85.9	3.2	66.7	87.6
7CG7084	Betaseed, 3-23-98	8997	25.19	17.85	152	86.4	3.4	56.7	78.6
7CG7328	Betaseed, 3-23-98	7857	21.01	18.70	130	85.3	3.7	45.0	82.0
Checks									
B4035R	Betaseed, 7-10-97	9463	28.22	16.85	169	86.1	3.0	77.9	90.5
R776-89-5H7	6911-4-7HO x R576-89-5	9829	28.42	17.30	188	85.1	3.2	68.8	87.6
US H11	L113102, 1997	4203	14.57	14.38	177	85.8	5.2	10.1	24.6
Mean		9201.1	26.18	17.49	180.0	86.3	3.4	62.5	79.4
LSD (.05)		1257.9	3.60	0.69	21.5	2.4	0.5	12.3	11.0
C.V. (%)		9.6	9.69	2.78	8.4	1.9	9.4	13.9	9.8
F value		21.1**	16.94**	22.07**	7.8**	1.7NS	29.7**	36.5**	44.0**

TEST 4498-2. WESTERN SUGAR, BETASEED, & USDA HYBRID EVALUATION UNDER RHIZOMANIA, SALINAS, CA., 1998

18 entries x 4 replications, RCB
1-row plots, 22 ft. long

Planted: April 28, 1998
Harvested: November 03, 1998

Variety	Description	Acre Yield		Sucrose	Beets/ 100'	RJAP
		Sugar Lbs	Beets Tons	%	No.	%
Western Sugar entries						
Beta A827R	Betaseed, 4-24-98	13901	37.19	18.70	183	85.3
HH-Rizor	Holly, 4-24-98	14353	40.21	17.86	204	85.5
Monohikari	Seedex, 4-24-98	11827	34.77	17.01	198	89.4
HM 1639	Novartis, 4-24-98	13754	38.90	17.69	202	86.2
Beta 826R	Betaseed, 4-24-98	14947	40.01	18.69	218	88.0
Beta 7CG9236LL	Betaseed transgenic	14665	37.44	19.60	206	86.4
Checks						
B4776R	Betaseed 4776.7653(3-27-98)	14146	39.71	17.84	198	87.0
B4038R	Betaseed, 16KJ090 (4-7-97)	16115	43.13	18.69	206	87.2
KW6770	Betassed, 6770.5193(1-10-97)	12544	34.47	18.21	206	87.8
Betaseed entries						
4CG6202	Betaseed, 3-23-98	12179	33.96	17.92	196	86.1
5KJ5017	Betaseed, 3-23-98	15366	41.92	18.33	198	87.8
6CG7229	Betaseed, 3-23-98	12336	33.56	18.35	179	85.5
6CG7265	Betaseed, 3-23-98	13806	39.30	17.56	204	87.1
7CG7084	Betaseed, 3-23-98	12602	36.58	17.23	175	85.1
7CG7328	Betaseed, 3-23-98	10416	28.47	18.30	152	86.2
Checks						
B4035R	Betaseed, 7-10-97	13049	37.39	17.45	190	87.0
R776-89-5H7	6911-4-7HO x R576-89-5	13405	38.29	17.51	200	86.0
US H11	L113102, 1997	9966	30.94	16.13	205	87.6
Mean		13298.9	37.01	17.95	195.5	86.7
LSD (.05)		1611.1	4.42	0.61	26.0	1.8
C.V. (%)		8.5	8.42	2.41	9.4	1.4
F value		8.1**	5.85**	12.95**	2.7**	3.3**

TEST 4398. CBGA SALINAS CODED RHIZOMANIA TEST, SALINAS, CA., 1998

78 entries x 8 replications, RCB
1-row plots, 22 ft. long

Planted: April 28, 1998
Harvested: (Rep. 1-4) October 27, 1998
(Rep. 5-8) November 04, 1998

Code No.	Variety	Source	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Beets/ 100' No.	RJAP %	Resistance DI	Resistance %R(0-4)	Root Rot %
SR- 1	97CX14	Spreckels	11147	32.24	17.24	191	86.6	3.6	83.1	0.0
SR- 2	H945187	Spreckels	9973	29.45	16.92	176	88.0	4.0	67.3	0.0
SR- 3	5CG7497	Betaseed	11633	33.44	17.38	204	86.6	3.5	79.2	0.0
SR- 4	97CX12	Spreckels	9934	28.76	17.24	198	86.8	3.4	92.9	0.0
SR- 5	Beta 4684R	Betaseed	11767	32.86	17.89	182	85.9	2.6	97.8	0.0
SR- 6	7CG7304	Betaseed	11585	34.28	16.93	193	85.1	3.7	75.7	0.0
SR- 7	97CX10	Spreckels	11865	32.80	18.08	212	85.8	3.4	88.2	0.0
SR- 8	SS-778R	Spreckels	10887	32.40	16.77	197	86.6	4.7	50.2	0.0
SR- 9	5CG7514	Betaseed	11648	32.09	18.16	209	87.3	3.5	88.4	0.0
SR- 10	4KJ0164	Betaseed	12801	36.81	17.33	212	88.5	3.0	98.4	0.0
SR- 11	6CG7281	Betaseed	12063	33.97	17.73	163	85.6	3.4	96.3	0.0
SR- 12	Beta 4035R	Betaseed	12470	34.72	17.94	205	86.4	2.9	95.5	0.0
SR- 13	SS-338R	Spreckels	9802	28.57	17.15	187	86.8	4.2	55.8	0.0
SR- 14	Beta 4776R	Betaseed	13333	36.86	18.11	209	87.3	2.9	96.2	0.0
SR- 15	98CX30	Spreckels	9971	30.16	16.58	183	86.2	3.8	74.3	0.0
SR- 16	97XC08	Spreckels	11327	31.21	18.22	224	87.1	3.3	87.8	0.0
SR- 17	SS-NB5R	Spreckels	10129	29.25	17.31	175	87.1	3.7	77.3	0.0
SR- 18	98CX19	Spreckels	10226	29.67	17.23	192	86.8	3.4	81.4	0.0
SR- 19	98CX16	Spreckels	11041	32.58	16.96	186	85.8	3.8	73.9	0.0
SR- 20	97CX09	Spreckels	11984	32.77	18.31	214	86.0	3.3	94.6	0.0
SR- 21	5CG7540	Betaseed	13613	38.40	17.73	201	87.7	3.0	94.5	0.0
SR- 22	5KJ0142	Betaseed	13769	38.44	17.85	196	88.2	2.0	98.9	0.0
SR- 23	SS-287R	Spreckels	9231	27.05	17.03	187	86.0	4.4	54.6	0.0
SR- 24	97CX11	Spreckels	10929	32.73	16.74	180	85.9	3.3	87.3	0.0
SR- 25	H95786	Spreckels	10437	31.28	16.60	216	86.3	4.4	54.8	0.0

TEST 4398. CBGA SALINAS CODED RHIZOMANIA TEST, SALINAS, CA., 1998

(cont.)

Code No.	Variety	Source	Acre Yield		Sucrose	Beets/ 100'	RJAP	Resistance		Root Rot
			Sugar Lbs	Beets Tons	%	No.	%	DI	%R(0-4)	%
SR- 26	97CX15	Spreckels	10989	31.27	17.54	179	87.1	3.4	86.3	0.0
SR- 27	97CX02	Spreckels	11967	34.61	17.24	185	88.4	3.4	90.4	0.0
SR- 28	98CX26	Spreckels	10483	29.85	17.54	191	86.2	3.5	88.3	0.0
SR- 29	H95504	Spreckels	11151	32.97	16.91	181	86.7	3.4	86.5	0.0
SR- 30	H93203	Spreckels	9646	28.39	16.83	210	86.4	4.4	52.3	0.6
SR- 31	Beta 4581	Betaseed	12399	34.34	18.03	202	87.4	2.8	93.8	0.0
SR- 32	SS-781R	Spreckels	10580	30.46	17.36	188	86.4	3.4	82.8	0.0
SR- 33	98CX19	Spreckels	10311	30.64	16.78	185	86.7	3.9	69.3	0.0
SR- 34	98CX22	Spreckels	10474	31.45	16.61	181	86.0	3.1	92.8	0.0
SR- 35	SS-694R	Spreckels	10564	31.13	16.95	183	86.5	3.5	83.2	0.0
SR- 36	3BG6156	Betaseed	11783	33.97	17.28	225	88.2	3.5	81.5	0.0
SR- 37	98CX27	Spreckels	10304	30.98	16.68	188	86.0	3.3	92.6	0.0
SR- 38	SS-289R	Spreckels	9730	28.35	17.15	200	86.0	4.0	61.0	0.0
SR- 39	7CG7376	Betaseed	14478	39.06	18.49	169	88.0	2.8	96.7	0.0
SR- 40	98CX21	Spreckels	11333	32.28	17.52	202	87.5	3.2	88.2	0.0
SR- 41	Rizor	Spreckels	11975	32.85	18.22	197	86.5	3.3	90.0	0.5
SR- 42	3BG6170	Betaseed	11591	33.12	17.51	200	87.3	4.3	58.7	0.6
SR- 43	Rival	Spreckels	11420	32.38	17.62	181	86.0	3.3	92.8	0.0
SR- 44	SS-NB2R2	Spreckels	10325	30.19	17.16	182	86.7	3.4	85.5	0.0
SR- 45	SS-432R	Spreckels	10775	31.13	17.31	169	86.3	3.8	76.4	0.0
SR- 46	SS-NB7R	Spreckels	10809	31.61	17.09	182	86.0	3.4	86.7	0.0
SR- 47	98CX28	Spreckels	10050	29.44	17.04	189	85.2	4.0	65.8	0.0
SR- 48	98CX29	Spreckels	11122	32.54	17.05	195	86.3	3.1	91.7	0.0
SR- 49	US H11	Standard	7216	22.91	15.44	166	87.2	5.3	25.8	0.0
SR- 50	98CX32	Spreckels	11854	34.59	17.12	180	86.6	3.4	86.9	0.0

TEST 4398. CBGA SALINAS CODED RHIZOMANIA TEST, SALINAS, CA., 1998

(cont.)

Code No.	Variety	Source	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Beets/ 100' No.	RJAP %	Resistance DI	Resistance %R(0-4)	Root Rot %
SR- 51	97CX01	Spreckels	10507	30.85	17.01	178	86.3	3.5	84.4	0.0
SR- 52	97CX06	Spreckels	11879	33.96	17.51	194	86.5	3.1	93.3	0.0
SR- 53	97CX13	Spreckels	10533	31.76	16.54	176	85.8	3.7	78.1	0.6
SR- 54	97CX04	Spreckels	11395	34.57	16.44	193	86.6	3.8	73.1	0.0
SR- 55	98CX31	Spreckels	11318	33.65	16.81	205	86.1	3.7	76.0	0.0
SR- 56	5KJ5061	Betaseed	10830	30.87	17.52	119	86.2	3.3	90.1	0.0
SR- 57	Rhizoguard	Spreckels	9439	28.84	16.38	192	86.4	4.0	59.0	0.0
SR- 58	98CX20	Spreckels	10719	32.29	16.54	198	86.3	3.5	81.5	0.0
SR- 59	98CX25	Spreckels	10692	32.31	16.56	185	87.8	3.3	88.0	0.0
SR- 60	2J5324	Betaseed	10961	30.38	18.07	176	87.0	3.8	79.8	0.0
SR- 61	Beta 4006R	Betaseed	10804	29.05	18.55	140	86.4	3.3	91.2	0.0
SR- 62	H93392	Spreckels	10835	31.61	17.14	205	85.7	3.2	90.1	0.0
SR- 63	4KJ0169	Betaseed	12679	36.55	17.34	215	87.8	3.1	94.2	0.5
SR- 64	98CX17	Spreckels	10574	31.80	16.59	198	87.3	3.3	84.9	0.0
SR- 65	HM 3048	Hilleshog	10323	29.74	17.29	191	86.2	3.6	74.9	0.0
SR- 66	98CX24	Spreckels	10530	30.77	17.10	184	85.9	3.4	85.4	0.0
SR- 67	H9555	Spreckels	10386	29.85	17.38	188	86.4	3.9	68.4	0.0
SR- 68	97CX07	Spreckels	10249	30.18	16.98	185	86.8	3.2	89.6	0.0
SR- 69	SS-IV2R	Spreckels	10276	30.44	16.89	162	86.8	3.8	75.4	0.0
SR- 70	3BG6224	Betaseed	12469	34.50	18.09	156	86.1	3.2	99.3	0.0
SR- 71	7CG7391	Betaseed	13446	37.64	17.81	196	87.2	3.6	90.0	0.0
SR- 72	4KJ0166	Betaseed	12295	34.89	17.59	220	87.9	3.0	94.3	0.0
SR- 73	Beta 4488R	Betaseed	11940	32.94	18.09	204	87.0	3.1	95.2	0.0
SR- 74	98CX23	Spreckels	10446	30.75	17.01	181	86.9	3.4	84.6	0.0
SR- 75	7CG7400	Betaseed	12276	35.16	17.48	195	86.7	3.3	92.1	0.0

TEST 4398. CBGA SALINAS CODED RHIZOMANIA TEST, SALINAS, CA., 1998

(cont.)

Code No.	Variety	Source	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Beets/ 100' No.	RJAP %	Resistance DI	Resistance %R(0-4)	Root Rot %
SR- 76	R776-89-5H31	USDA	10814	31.01	17.44	173	86.2	3.2	91.1	0.0
SR- 77	R736H50	USDA	11420	33.81	16.87	197	85.3	3.4	82.6	0.0
SR- 78	US H11	USDA	7122	23.20	15.07	175	86.8	5.3	24.2	0.0
Mean			11077.6	32.01	17.26	189.5	86.6	3.5	81.6	0.04
LSD (.05)			1229.8	3.44	0.49	19.0	1.4	0.4	11.5	0.40
C.V. (%)			11.3	10.95	2.87	10.2	1.7	9.0	10.2	791.11
F value			7.7**	5.45**	12.45**	6.5**	2.2**	10.9**	13.6**	0.95NS

NOTES: Test 4398 was planted into two 78 variety x 4 replication sections, 4398-1 and 4398-2. Test 4398 was analyzed and summarized three ways: 4398(78V x 8R,RCB); 4398-1(78V x 4R, RCB); and 4398-2(78V x 4R,RCB). 4398-1 was in an area of the field that had uniform and moderate levels of rhizomania. 4398-2 was in an area nearby, but had light to mild rhizomania. After visual inspection, test 4398-1 was chosen for hand harvest and scoring individual plants for rhizomania. 4398-2 was machine harvested and was not scored for rhizomania.

Rhizomania was scored on a scale of 0 to 9 where 9 = severe. Because rhizomania was moderate, root symptoms formed a continuum and it was not completely obvious where to draw the line between resistance and susceptibility. Disease reaction for US H11 suggested that classes 0-3 were resistant and 4-9 susceptible. However, resistant varieties suggested that 0-4 was resistant and 5-9 susceptible with regards to the *Rz* gene. In table 4398-1, analyses were run both ways. Probably, where 0-3 = resistant, the frequency of resistant plants was underestimated; where 0-4 = resistant, the frequency of resistant plants was overestimated. DI = disease index is the weighted mean of the ratings for each variety where a lower value suggests higher resistance.

TEST 4398-1. CBGA SALINAS CODED RHIZOMANIA TEST, SALINAS, CA., 1998

78 entries x 4 replications, RCB
1-row plots, 22 ft. long

Planted: April 28, 1998
Harvested: October , 1998

Code No.	Variety	Source	Acre Yield		Sucrose	Beets/ 100'	RJAP	Resistance		
			Sugar Lbs	Beets Tons	%	No.	%	DI	%R(0-4)	%R(0-3)
SR- 1	97CX14	Spreckels	9343	26.99	17.23	185	85.8	3.6	83.1	51.3
SR- 2	H945187	Spreckels	8208	24.44	16.79	159	88.3	4.0	67.3	37.7
SR- 3	5CG7497	Betaseed	10144	29.59	17.15	198	86.1	3.5	79.2	56.7
SR- 4	97CX12	Spreckels	7810	22.75	17.15	196	87.7	3.4	92.9	60.0
SR- 5	Beta 4684R	Betaseed	10142	28.10	17.98	183	85.2	2.6	97.8	83.0
SR- 6	7CG7304	Betaseed	9627	27.84	17.24	195	85.7	3.7	75.7	52.6
SR- 7	97CX10	Spreckels	10551	29.43	17.95	200	85.3	3.4	88.2	68.4
SR- 8	SS-778R	Spreckels	8395	25.19	16.67	197	87.0	4.7	50.2	34.1
SR- 9	5CG7514	Betaseed	8384	23.07	18.13	209	87.6	3.5	88.4	56.0
SR- 10	4KJ0164	Betaseed	9742	28.58	17.05	202	88.1	3.0	98.4	79.1
SR- 11	6CG7281	Betaseed	10146	28.63	17.70	159	84.8	3.4	96.3	58.2
SR- 12	Beta 4035R	Betaseed	9841	27.52	17.88	191	85.8	2.9	95.5	80.8
SR- 13	SS-338R	Spreckels	7631	22.27	17.13	181	86.2	4.2	55.8	41.7
SR- 14	Beta 4776R	Betaseed	11036	30.28	18.24	207	87.6	2.9	96.2	80.5
SR- 15	98CX30	Spreckels	7605	23.04	16.63	164	86.7	3.8	74.3	49.1
SR- 16	97XC08	Spreckels	8400	22.92	18.40	228	86.6	3.3	87.8	69.2
SR- 17	SS-NB5R	Spreckels	7743	22.22	17.38	163	87.3	3.7	77.3	51.6
SR- 18	98CX19	Spreckels	8230	23.97	17.17	182	86.9	3.4	81.4	58.7
SR- 19	98CX16	Spreckels	8937	26.26	17.01	177	86.5	3.8	73.9	49.2
SR- 20	97CX09	Spreckels	10487	28.32	18.51	204	86.3	3.3	94.6	62.1
SR- 21	5CG7540	Betaseed	11969	33.67	17.77	184	88.2	3.0	94.5	77.3
SR- 22	5KJ0142	Betaseed	11278	32.03	17.59	193	87.7	2.0	98.9	94.0
SR- 23	SS-287R	Spreckels	7090	20.94	16.94	190	85.6	4.4	54.6	37.0
SR- 24	97CX11	Spreckels	8286	24.74	16.76	163	85.8	3.3	87.3	64.8
SR- 25	H95786	Spreckels	7479	22.96	16.27	210	85.9	4.4	54.8	37.6

TEST 4398-1. CBGA SALINAS CODED RHIZOMANIA TEST, SALINAS, CA., 1998

(cont.)

Code No.	Variety	Source	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Beets/ 100' No.	RJAP %	Resistance DI	Resistance %R(0-4)	Resistance %R(0-3)
SR- 26	97CX15	Spreckels	8182	23.54	17.41	172	86.9	3.4	86.3	59.4
SR- 27	97CX02	Spreckels	9519	28.10	16.95	163	88.5	3.4	90.4	62.1
SR- 28	98CX26	Spreckels	8780	25.24	17.40	175	86.9	3.5	88.3	59.0
SR- 29	H95504	Spreckels	9674	28.95	16.74	167	86.4	3.4	86.5	61.4
SR- 30	H93203	Spreckels	6852	21.10	16.23	205	85.5	4.4	52.3	31.5
SR- 31	Beta 4581	Betaseed	10226	28.58	17.89	190	87.1	2.8	93.8	78.0
SR- 32	SS-781R	Spreckels	9179	26.35	17.36	191	86.1	3.4	82.8	64.9
SR- 33	98CX19	Spreckels	8756	26.62	16.45	180	86.4	3.9	69.3	48.9
SR- 34	98CX22	Spreckels	8417	25.82	16.31	182	85.1	3.1	92.8	74.5
SR- 35	SS-694R	Spreckels	8126	24.07	16.89	182	86.5	3.5	83.2	56.6
SR- 36	3BG6156	Betaseed	9087	26.72	17.00	231	87.8	3.5	81.5	59.2
SR- 37	98CX27	Spreckels	8406	24.87	16.91	187	86.2	3.3	92.6	66.4
SR- 38	SS-289R	Spreckels	7327	21.53	17.05	188	86.6	4.0	61.0	51.0
SR- 39	7CG7376	Betaseed	11969	32.66	18.29	167	87.2	2.8	96.7	86.6
SR- 40	98CX21	Spreckels	8857	25.45	17.39	197	87.7	3.2	88.2	75.1
SR- 41	Rizor	Spreckels	10279	28.21	18.21	185	86.5	3.3	90.0	67.5
SR- 42	3BG6170	Betaseed	9511	27.04	17.56	198	87.2	4.3	58.7	35.0
SR- 43	Rival	Spreckels	9745	27.79	17.54	174	85.9	3.3	92.8	68.1
SR- 44	SS-NB2R2	Spreckels	7929	22.80	17.40	173	87.3	3.4	85.5	61.7
SR- 45	SS-432R	Spreckels	9193	26.78	17.19	184	85.7	3.8	76.4	48.7
SR- 46	SS-NB7R	Spreckels	9032	26.51	17.05	175	85.7	3.4	86.7	65.4
SR- 47	98CX28	Spreckels	8414	24.92	16.86	196	85.0	4.0	65.8	48.0
SR- 48	98CX29	Spreckels	8450	25.08	16.85	196	86.0	3.1	91.7	66.7
SR- 49	US H11	Standard	4264	14.58	14.64	172	86.9	5.3	25.8	10.0
SR- 50	98CX32	Spreckels	10129	29.98	16.90	169	86.4	3.4	86.9	58.8

TEST 4398-1. CBGA SALINAS CODED RHIZOMANIA TEST, SALINAS, CA., 1998

(cont.)

Code No.	Variety	Source	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Beets/ 100' No.	RJAP %	Resistance DI	Resistance %R(0-4)	Resistance %R(0-3)
SR- 51	97CX01	Spreckels	8675	26.04	16.71	166	85.6	3.5	84.4	53.4
SR- 52	97CX06	Spreckels	10583	30.22	17.56	198	86.0	3.1	93.3	72.6
SR- 53	97CX13	Spreckels	9272	28.66	16.19	160	85.6	3.7	78.1	51.3
SR- 54	97CX04	Spreckels	9553	29.64	16.13	184	86.0	3.8	73.1	50.8
SR- 55	98CX31	Spreckels	9430	28.10	16.79	196	86.3	3.7	76.0	53.5
SR- 56	5KJ5061	Betaseed	8961	25.64	17.48	125	85.8	3.3	90.1	60.1
SR- 57	Rhizoguard	Spreckels	6898	21.00	16.42	179	85.1	4.0	59.0	47.1
SR- 58	98CX20	Spreckels	8628	26.49	16.25	187	85.5	3.5	81.5	60.0
SR- 59	98CX25	Spreckels	9296	27.84	16.69	188	88.1	3.3	88.0	64.0
SR- 60	2J5324	Betaseed	8332	23.01	18.13	162	86.7	3.8	79.8	44.5
SR- 61	Beta 4006R	Betaseed	9148	25.35	18.06	131	85.5	3.3	91.2	63.9
SR- 62	H93392	Spreckels	8497	24.92	17.09	189	86.0	3.2	90.1	66.7
SR- 63	4KJ0169	Betaseed	10548	30.67	17.20	205	87.3	3.1	94.2	77.2
SR- 64	98CX17	Spreckels	8066	24.50	16.44	184	85.8	3.3	84.9	67.8
SR- 65	HM 3048	Hilleshog	7425	21.79	17.04	188	85.1	3.6	74.9	60.7
SR- 66	98CX24	Spreckels	9055	26.67	16.98	183	86.2	3.4	85.4	60.8
SR- 67	H9555	Spreckels	8029	23.22	17.29	176	85.7	3.9	68.4	45.6
SR- 68	97CX07	Spreckels	8536	25.40	16.83	176	87.1	3.2	89.6	68.9
SR- 69	SS-IV2R	Spreckels	8685	25.61	16.96	142	86.7	3.8	75.4	49.7
SR- 70	3BG6224	Betaseed	10283	28.32	18.17	171	86.2	3.2	99.3	66.6
SR- 71	7CG7391	Betaseed	11062	31.55	17.51	187	86.8	3.6	90.0	51.6
SR- 72	4KJ0166	Betaseed	9810	28.26	17.40	218	87.9	3.0	94.3	72.3
SR- 73	Beta 4488R	Betaseed	10656	30.01	17.75	205	87.4	3.1	95.2	70.7
SR- 74	98CX23	Spreckels	8936	26.03	17.16	176	86.6	3.4	84.6	61.5
SR- 75	7CG7400	Betaseed	10239	29.32	17.49	197	87.3	3.3	92.1	64.3

TEST 4398-1. CBGA SALINAS CODED RHIZOMANIA TEST, SALINAS, CA., 1998

(cont.)

Code No.	Variety	Source	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Beets/ 100' No.	RJAP %	Resistance DI	Resistance %R(0-4)	Resistance %R(0-3)
SR- 76	R776-89-5H31	USDA	9056	26.14	17.36	175	86.5	3.2	91.1	67.3
SR- 77	R736H50	USDA	9612	28.83	16.68	180	84.7	3.4	82.6	57.8
SR- 78	US H11	USDA	4111	14.16	14.41	168	85.9	5.3	24.2	8.0
Mean			8976.8	26.11	17.15	183.5	86.5	3.5	81.6	58.9
LSD (.05)			1864.4	5.16	0.77	25.2	2.2	0.4	11.5	15.8
C.V. (%)			14.9	14.18	3.23	9.8	1.9	9.0	10.2	19.2
F value			4.2**	3.47**	6.56**	4.2**	1.3NS	10.9**	13.6**	7.0**

TEST 4398-2. CBGA SALINAS CODED RHIZOMANIA TEST, SALINAS, CA., 1998

78 entries x 4 replications, RCB
1-row plots, 22 ft. long

Planted: April 28, 1998
Harvested: November 3, 1998

Code No.	Variety	Source	Acre Yield		Sucrose	Beets/ 100'	Root Rot	RJAP
			Sugar Lbs	Beets Tons	%	No.	%	%
SR- 1	97CX14	Spreckels	12952	37.49	17.26	196	0.0	87.5
SR- 2	H945187	Spreckels	11739	34.47	17.05	193	0.0	87.7
SR- 3	5CG7497	Betaseed	13122	37.29	17.60	209	0.0	87.0
SR- 4	97CX12	Spreckels	12058	34.77	17.34	200	0.0	85.9
SR- 5	Beta 4684R	Betaseed	13391	37.62	17.80	181	0.0	86.6
SR- 6	7CG7304	Betaseed	13544	40.71	16.63	192	0.0	84.4
SR- 7	97CX10	Spreckels	13179	36.18	18.21	223	0.0	86.4
SR- 8	SS-778R	Spreckels	13379	39.60	16.88	198	0.0	86.1
SR- 9	5CG7514	Betaseed	14911	41.12	18.19	209	0.0	87.0
SR- 10	4KJ0164	Betaseed	15860	45.05	17.60	221	0.0	88.8
SR- 11	6CG7281	Betaseed	13980	39.30	17.76	166	0.0	86.3
SR- 12	Beta 4035R	Betaseed	15100	41.92	18.01	218	0.0	86.9
SR- 13	SS-338R	Spreckels	11974	34.87	17.17	193	0.0	87.4
SR- 14	Beta 4776R	Betaseed	15631	43.43	17.99	212	0.0	87.1
SR- 15	98CX30	Spreckels	12337	37.29	16.54	202	0.0	85.6
SR- 16	97XC08	Spreckels	14254	39.50	18.04	220	0.0	87.6
SR- 17	SS-NB5R	Spreckels	12515	36.28	17.25	187	0.0	86.9
SR- 18	98CX19	Spreckels	12223	35.37	17.28	202	0.0	86.6
SR- 19	98CX16	Spreckels	13144	38.90	16.90	195	0.0	85.1
SR- 20	97CX09	Spreckels	13481	37.21	18.11	224	0.0	85.6
SR- 21	5CG7540	Betaseed	15258	43.13	17.69	217	0.0	87.2
SR- 22	5KJ0142	Betaseed	16260	44.84	18.11	198	0.0	88.8
SR- 23	SS-287R	Spreckels	11373	33.15	17.13	184	0.0	86.4
SR- 24	97CX11	Spreckels	13572	40.71	16.73	198	0.0	86.0
SR- 25	H95786	Spreckels	13395	39.60	16.92	221	0.0	86.7

TEST 4398-2. CBGA SALINAS CODED RHIZOMANIA TEST, SALINAS, CA., 1998

(cont.)

Code No.	Variety	Source	Acre Yield		Sucrose	Beets/ 100'	Root Rot	RJAP
			Sugar Lbs	Beets Tons	%	No.	%	%
SR- 26	97CX15	Spreckels	13796	39.00	17.66	187	0.0	87.3
SR- 27	97CX02	Spreckels	14416	41.12	17.54	207	0.0	88.3
SR- 28	98CX26	Spreckels	12185	34.47	17.67	206	0.0	85.5
SR- 29	H95504	Spreckels	12628	36.98	17.08	195	0.0	87.0
SR- 30	H93203	Spreckels	12440	35.67	17.44	215	0.6	87.2
SR- 31	Beta 4581	Betaseed	14573	40.11	18.18	214	0.0	87.8
SR- 32	SS-781R	Spreckels	11981	34.57	17.36	184	0.0	86.7
SR- 33	98CX19	Spreckels	11866	34.67	17.11	191	0.0	87.0
SR- 34	98CX22	Spreckels	12531	37.09	16.90	181	0.0	87.0
SR- 35	SS-694R	Spreckels	13003	38.19	17.01	183	0.0	86.4
SR- 36	3BG6156	Betaseed	14478	41.22	17.56	220	0.0	88.7
SR- 37	98CX27	Spreckels	12201	37.09	16.45	189	0.0	85.7
SR- 38	SS-289R	Spreckels	12134	35.17	17.25	213	0.0	85.5
SR- 39	7CG7376	Betaseed	16986	45.45	18.69	172	0.0	88.8
SR- 40	98CX21	Spreckels	13809	39.10	17.65	208	0.0	87.3
SR- 41	Rizor	Spreckels	13671	37.49	18.23	208	0.5	86.5
SR- 42	3BG6170	Betaseed	13671	39.20	17.45	201	0.6	87.4
SR- 43	Rival	Spreckels	13095	36.98	17.70	188	0.0	86.1
SR- 44	SS-NB2R2	Spreckels	12721	37.59	16.91	191	0.0	86.1
SR- 45	SS-432R	Spreckels	12358	35.47	17.44	154	0.0	86.9
SR- 46	SS-NB7R	Spreckels	12586	36.72	17.14	189	0.0	86.2
SR- 47	98CX28	Spreckels	11687	33.96	17.21	183	0.0	85.4
SR- 48	98CX29	Spreckels	13795	40.01	17.25	195	0.0	86.7
SR- 49	US H11	Standard	10168	31.24	16.24	160	0.0	87.5
SR- 50	98CX32	Spreckels	13579	39.20	17.34	191	0.0	86.9

TEST 4398-2. CBGA SALINAS CODED RHIZOMANIA TEST, SALINAS, CA., 1998

(cont.)

Code No.	Variety	Source	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Beets/ 100' No.	Root Rot %	RJAP %
SR- 51	97CX01	Spreckels	12340	35.67	17.31	190	0.0	86.9
SR- 52	97CX06	Spreckels	13176	37.69	17.45	190	0.0	87.0
SR- 53	97CX13	Spreckels	11793	34.87	16.90	192	0.6	86.0
SR- 54	97CX04	Spreckels	13237	39.50	16.75	201	0.0	87.2
SR- 55	98CX31	Spreckels	13206	39.20	16.83	214	0.0	85.9
SR- 56	5KJ5061	Betaseed	12699	36.11	17.58	114	0.0	86.6
SR- 57	Rhizoguard	Spreckels	11979	36.68	16.33	205	0.0	87.8
SR- 58	98CX20	Spreckels	12810	38.09	16.83	209	0.0	87.0
SR- 59	98CX25	Spreckels	12087	36.78	16.43	183	0.0	87.5
SR- 60	2J5324	Betaseed	13589	37.74	18.01	191	0.0	87.3
SR- 61	Beta 4006R	Betaseed	12459	32.74	19.04	149	0.0	87.3
SR- 62	H93392	Spreckels	13172	38.29	17.20	221	0.0	85.4
SR- 63	4KJ0169	Betaseed	14811	42.43	17.48	225	0.5	88.3
SR- 64	98CX17	Spreckels	13082	39.10	16.74	212	0.0	88.8
SR- 65	HM 3048	Hilleshog	13222	37.69	17.54	193	0.0	87.3
SR- 66	98CX24	Spreckels	12005	34.87	17.23	184	0.0	85.6
SR- 67	H9555	Spreckels	12743	36.48	17.46	199	0.0	87.2
SR- 68	97CX07	Spreckels	11961	34.97	17.13	195	0.0	86.6
SR- 69	SS-IV2R	Spreckels	11867	35.27	16.83	182	0.0	86.8
SR- 70	3BG6224	Betaseed	14655	40.69	18.01	142	0.0	86.1
SR- 71	7CG7391	Betaseed	15831	43.74	18.10	205	0.0	87.6
SR- 72	4KJ0166	Betaseed	14779	41.52	17.79	221	0.0	88.0
SR- 73	Beta 4488R	Betaseed	13223	35.88	18.43	202	0.0	86.7
SR- 74	98CX23	Spreckels	11957	35.47	16.86	187	0.0	87.2
SR- 75	7CG7400	Betaseed	14314	40.99	17.46	192	0.0	86.2

TEST 4398-2. CBGA SALINAS CODED RHIZOMANIA TEST, SALINAS, CA., 1998

(cont.)

Code No.	Variety	Source	Acre Yield		Sucrose	Beets/ 100'	Root Rot	RJAP
			Sugar Lbs	Beets Tons	%	No.	%	%
SR- 76	R776-89-5H31	USDA	12572	35.88	17.52	171	0.0	85.9
SR- 77	R736H50	USDA	13229	38.80	17.06	215	0.0	85.8
SR- 78	US H11	USDA	10133	32.25	15.73	182	0.0	87.7
Mean			13178.4	37.91	17.37	195.5	0.04	86.8
LSD (.05)			1528.4	4.25	0.56	27.3	0.40	1.8
C.V. (%)			8.3	8.05	2.32	10.0	791.11	1.5
F value			5.4**	3.90**	8.28**	4.0**	0.95NS	2.1**

TEST B198. EVALUATION OF TESTCROSS HYBRIDS, IMPERIAL VALLEY, 1997-98

32 entries x 8 replications, RCB(E)
1-row plots, 27 ft. long

Planted: September 10, 1997
Harvested: June 4, 1998

Variety	Description	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Beets/ 100' No.	Bolters %	Clean Beets %	NO3-N Mean
Checks								
Rizor	9-3-97	11447	36.37	15.69	176	27.1	94.0	142
SS-781R	9501614C (9-3-97)	10906	38.39	14.15	170	2.8	95.7	162
B4776R	Beta 4776R.7033 (9-1-97)	10202	32.40	15.71	171	1.7	94.8	189
Self-sterile,O.P. breeding lines								
R576-89-18H50	F92-790-15CMS x R476-89-18	12363	38.47	16.11	165	5.7	94.2	75
Y772H50	F92-790-15CMS x RZM Y672	11743	37.74	15.52	167	6.2	94.2	119
Y771H50	F92-790-15CMS x RZM Y671	11494	38.69	14.91	169	15.1	94.3	163
R778H50	F92-790-15CMS x R678	11271	38.14	14.74	159	2.8	95.1	139
R776-89-5H50	F92-790-15CMS x R576-89-5	11089	35.18	15.73	162	6.9	94.7	98
Y774H50	F92-790-15CMS x Y74(C)	10841	36.73	14.78	166	8.1	93.6	161
Y769H50	F92-790-15CMS x Y669	10568	36.72	14.34	166	10.6	94.5	191
Y773H50	F92-790-15CMS x RZM Y673R	10438	35.43	14.73	166	10.3	95.0	142
C79-# breeding lines								
R779H50	F92-790-15CMS x RZM R679	11149	40.08	13.91	173	22.5	95.1	226
R736H50	F92-790-15CMS x RZM R636	10477	36.20	14.48	171	11.2	92.8	186
R753H50	F92-790-15CMS x RZM R653	10172	34.22	14.85	169	7.0	92.2	142
R746H50(Sp)	F92-790-15CMS x RZM R646,R653	10084	33.75	14.94	163	6.8	92.4	114
R746H50(Iso)	F92-790-15CMS x RZM R646	9901	33.53	14.71	170	7.9	92.4	153
R735H50	F92-790-15CMS x RZM R635	9676	32.90	14.71	168	10.2	93.9	116
Self-fertile,Aa,random-mated populations								
7931H50	F92-790-15CMS x 931(C)	11833	40.11	14.70	168	7.4	92.9	124
7926H50	F92-790-15CMS x 926(C)	11741	38.15	15.35	167	15.6	93.2	86
7933H50	F92-790-15CMS x 6264-#(C)	11398	36.51	15.60	170	13.5	93.7	75
Z731H50	F92-790-15CMS x Z31(C)	11318	37.66	14.93	162	15.1	93.6	170
7932CTH50	F92-790-15CMS x 6260-63-#(C)	10852	35.59	15.30	171	18.4	92.5	131
CR711H50	F92-790-15CMS x CR11(C)	10616	37.22	14.30	162	18.8	94.4	186
7924H50	F92-790-15CMS x 924(C)	9969	34.22	14.57	163	15.3	92.6	150

TEST B198. EVALUATION OF TESTCROSS HYBRIDS, IMPERIAL VALLEY, 1997-98

(cont.)

Variety	Description	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Beets/ 100' No.	Bolters %	Clean Beets %	NO3-N Mean
S_1 et al. progeny lines from S^f,Aa popns								
6913-70H50	F92-790-15CMS x 5913-70	12660	41.32	15.36	172	19.0	93.3	136
7918-21H50	F92-790-15CMS x RZM 6918-21	12344	41.14	15.03	165	6.0	93.9	107
6918-3H50	F92-790-15CMS x RZM 4918-3	12254	39.20	15.62	175	7.9	90.0	97
6918-12H50	F92-790-15CMS x RZM 4918-2	11691	37.91	15.35	168	11.5	93.2	81
7911-4-10H50	F92-790-15CMS x RZM 6911-4-10	11574	36.16	16.00	173	5.0	91.2	67
Testcrosses to C306/2 CMS								
R776-89-5H37	4807HO (C306/2CMS) x R576-89-5	12038	40.37	14.87	162	1.4	94.7	131
R778H37	4807HO (C306/2CMS) x R678	11236	41.27	13.59	160	1.1	93.5	121
Y769H37	4807HO (C306/2CMS) x Y669	10613	40.19	13.18	167	4.8	92.9	195
Mean		11123.7	37.25	14.93	167.3	10.1	93.6	136.6
LSD (.05)		1144.6	3.28	0.78	11.4	5.8	1.5	68.9
C.V. (%)		10.5	8.95	5.28	6.9	57.8	1.6	51.2
F value		3.7**	4.53**	5.90**	1.1NS	9.7**	5.2**	2.6**

NOTES: Test appeared to be 100% infected with whitefly vectored lettuce chlorosis virus (LCV). Bolting was more severe than usual or in recent years. Winter was mild and up through harvest, temperatures were consistently unseasonably cool. Powdery mildew developed late after being controlled with sulfur. Mites and Empoasca were moderate at harvest. Rhizomania was observed on a few roots but not considered to be significant. Spring flight of beet leaf hoppers occurred and adjacent March planted sugarbeets were 100% infected with CTV.

F92-790-15CMS = C790-68CMS x C790-15. R678 ≈ C78. Y669 ≈ C69. Y672 ≈ C72. Y74(C) ≈ C69 with *Bvm* resistance to rhizomania. Y671,Y672, & Y673R have resistance to rhizomania from *Bvm* line R22 (C51). R476-89-18 ≈ C76-89-18 & R576-89-5 ≈ C76-89-5 are increases of full-sib families from C76-89 (≈ C31-89*Rz*). R679 ≈ C79-1 ≈ C37*Rz*. R636 ≈ C79-8 ≈ C37 with resistance from R22. R646 & R653 are continued backcrosses to C37. R635 ≈ C79-7 ≈ C37 with resistance from 'Rima.' 931(C) ≈ C918, the programs primary MM,S^f,Aa,*Rz* random-mated popn. 926(C) ≈ 931(C) with R22 resistance. Z31(C) ≈ CZ25 ≈ 931(C) with high %S Polish germplasm. CR11(C) ≈ CR09,10 with resistance to Cercospora leaf spot. 6264 ≈ 931(C) with root aphid resistance. 6260-63 ≈ 931(C) with CTR. 924(C) ≈ 931(C) with improved VYR. 5913-70 = C913-70. 4918-2,4918-3, & 4918-21 = increases of S_1 progeny from popn-918; 6911-4-10 from popn-911-4.

TEST B398. EVALUATION OF TOPCROSS HYBRIDS, IMPERIAL VALLEY, 1997-98

32 entries x 8 replications, RCB(E)
1-row plots, 27 ft. long

Planted: September 11, 1997
Harvested: May 12, 1998

Variety	Description	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Beets/ 100' No.	Bolters %	Clean Beets %	NO3-N Mean
Checks								
Rizor	9-3-97	11127	35.31	15.77	178	14.2	94.2	65
SS-781	9-3-97	10129	34.48	14.68	172	2.8	95.1	98
B4776R	Beta 4776.7033 (9-1-97)	9695	30.75	15.80	175	1.6	93.0	126
Topcrossed with C78								
R778H7	6911-4-7HO x R678	11324	36.23	15.63	159	2.1	93.6	50
R778H37	4807HO(C306/2CMS) x R678	10973	36.48	15.07	153	0.6	93.5	72
R778H69	6869aa x R678	10804	34.98	15.46	163	1.4	95.9	50
R778H50	F92-790-15CMS x R678	10714	33.60	15.95	159	3.5	94.1	63
R778H31-4	6831-4aa x R678	10687	35.26	15.21	161	0.0	95.0	92
R778H8	F82-546H3 x R678	9261	30.64	15.12	156	0.3	94.4	73
Topcrossed with C69								
Y769H50	F92-790-15CMS x Y669	10792	35.65	15.12	165	5.7	94.2	87
Y769H69	6869aa x Y669	10498	34.99	14.99	167	4.4	95.9	82
Y769H37	4807HO(C306/2CMS) x Y669	10465	37.97	13.85	168	0.8	94.1	141
Y769H7	6911-4-7HO x Y669	9957	34.08	14.59	166	20.3	93.2	98
Topcrossed with C76-89-5								
R776-89-5H37	4807HO(C306/2CMS) x R576-89-5	11984	37.94	15.82	161	0.2	93.2	43
R776-89-5H50	F92-790-15CMS x R576-89-5	10440	32.18	16.21	160	6.0	93.5	53
R776-89-5H27	6831-4HO x R576-89-5	10424	33.46	15.56	157	1.1	93.2	51
R776-89-5H7	6911-4-7HO x R576-89-5	10083	32.20	15.68	151	12.3	93.8	52
R776-89-5H69	6869aa x R576-89-5	9939	31.41	15.82	161	2.6	94.9	57

TEST B398. EVALUATION OF TOPCROSS HYBRIDS, IMPERIAL VALLEY, 1997-98 (B398)

(cont.)

Variety	Description	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Beets/ 100' No.	Bolters %	Clean Beets %	NO3-N Mean
Topcrossed with Y74								
Y774H50	F92-790-15CMS x Y74(C)	11272	35.90	15.71	163	8.4	94.1	71
Y774H37	4807HO(C306/2CMS) x Y74(C)	11174	38.61	14.44	162	5.7	94.0	79
Y774H69	6869aa x Y74(C)	10351	34.60	14.95	166	3.4	95.0	72
Topcrossed with popn-931								
7931H37	4807HO(C306/2CMS) x 931(C)	11012	38.89	14.18	165	2.9	93.2	90
7931H50	F92-790-15CMS x 931(C)	10613	33.64	15.86	162	8.0	93.3	59
7931H69	6869aa x 931(C)	10436	34.55	15.11	161	3.9	94.7	55
Topcrossed with popn-CZ25								
Z731H37	4807HO(C306/2CMS) x Z31(C)	11110	38.13	14.55	160	3.1	94.2	111
Z731H50	F92-790-15CMS x Z31(C)	10531	33.66	15.64	163	9.6	93.1	46
Z731H69	6869aa x Z31(C)	10194	32.74	15.55	168	6.6	94.7	65
Topcrossed to other pollinators								
7926H69	6869aa x 926(C)	10720	35.80	14.98	165	6.4	93.7	75
7924H37	4807HO(C306/2CMS) x 924(C)	10662	37.38	14.23	166	4.4	92.9	94
7924H50	F92-790-15CMS x 924(C)	10388	33.11	15.67	164	10.1	92.7	54
CR711H69	6869aa x CR11(C)	10027	34.18	14.61	166	5.3	94.1	79
7924H69	6869aa x 924(C)	9699	32.84	14.79	164	8.2	94.2	87
Mean		10546.3	34.74	15.21	163.4	5.2	94.0	74.7
LSD (.05)		892.4	2.62	0.79	11.3	3.9	1.5	47.4
C.V. (%)		8.6	7.64	1.60	7.0	77.2	1.6	64.4
F value		3.0**	5.63**	2.42**	1.9NS	10.3**	2.4**	1.9**

NOTES: See test B198. F82-546H3 = (C562CMS x C546) = the female of US H9, US H10, US H11, & USC-1.

TEST B498. EVALUATION OF POPULATION HYBRIDS, IMPERIAL VALLEY, 1997-98

16 entries x 8 replications, RCB(E)
1-row plots, 27 ft. long

Planted: September 11, 1997
Harvested: May 12, 1998

Variety	Description	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Beets/ 100' No.	Bolters %	Clean Beets %	NO3-N Mean
Checks								
B4776R	Beta 4776.7033 (9-1-97)	9719	30.00	16.21	166	0.9	95.6	77
Rizor	9-3-97	10203	32.19	15.85	175	20.1	95.7	86
Popn hybrids								
R778H33	6833aa x R678	10999	35.63	15.44	159	3.0	96.2	73
R778H38M	6837Maa x R678	10540	35.54	14.84	155	2.2	95.4	78
R778H33%	6833%aa x R678	10430	33.88	15.37	161	4.6	96.6	84
R778H50	F92-790-15CMS x R678	10350	32.89	15.73	161	3.8	95.8	72
R778H34	6834%aa x R678	10087	32.01	15.75	169	3.8	94.6	71
R778H28	6828aa x R678	9769	31.20	15.69	164	8.9	96.5	46
R778H36	6836aa x R678	9686	30.46	15.88	162	2.4	95.2	66
Hybrids of C890-#								
R778H18	6818maa x R678	10765	33.89	15.91	164	2.2	95.1	55
R778H17M	6817Maa x R678	9772	31.21	15.65	156	1.0	95.5	58
R778H12	6812maa x R678	8417	27.02	15.52	156	15.3	95.1	48
R778H87	5890aa x R678	8344	26.67	15.63	171	1.7	95.1	41
Hybrids to progeny line								
R778H31-4	6831-4aa x R678	10071	33.74	14.97	158	0.0	96.4	60
R778H59-8	6859-8aa x R678	9855	30.42	16.16	152	1.9	96.1	72
R778H93	6891-10HO x R678	9664	31.76	15.19	174	2.2	95.7	74
Mean		9917.0	31.78	15.61	162.8	4.6	95.7	66.3
LSD (.05)		868.7	2.51	0.62	14.0	2.8	1.5	30.6
C.V. (%)		8.9	7.97	3.99	8.7	60.5	1.6	46.7
F value		5.4**	8.26	3.03	1.9*	31.5**	1.2NS	15.0NS

NOTES: See test B198. 5890 = C890-1. 6812 = C890-2. 6817 = C890-7. 6818 = C890-8 with rhizomania resistance from R22 (C51).

TEST B298. AREA 5 CODED NON-RHIZOMANIA YIELD TEST, IMPERIAL VALLEY, 1997-98

32 entries x 8 reps., RCB(E)
1-row plots, 27 ft. long

Planted: September 11, 1997
Harvested: June 2-4, 1998

Code	Variety	Source	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Beets/ 100' No.	Bolters %	Clean Beets %	NO3-N Mean
CBGA entries									
A5N - 1	97CX06	Spreckels	10594	33.63	15.78	165	1.7	94.6	89
- 2	Beta 4006R	Betaseed	10774	32.30	16.65	177	1.0	93.9	57
- 3	SS-781R	Spreckels	11099	37.29	14.95	172	3.8	95.1	114
- 4	97CX10	Spreckels	11026	33.24	16.57	177	14.5	94.7	70
- 5	97CX07	Spreckels	10918	35.76	15.28	173	9.8	95.4	152
- 6	7CG7391	Betaseed	11318	40.01	14.05	168	2.8	94.6	255
- 7	97CX04	Spreckels	11145	38.60	14.48	182	10.4	94.7	142
- 8	Rival	Spreckels	11059	33.98	16.29	180	22.5	92.8	99
- 9	Beta 4035R	Betaseed	11697	36.07	16.19	178	3.9	94.9	119
-10	SS-694R	Spreckels	9467	32.27	14.72	176	8.7	94.6	124
-11	5KJ0142	Betaseed	12092	36.39	16.66	179	0.5	95.2	106
-12	7CG7400	Betaseed	11729	36.35	16.14	175	3.1	94.3	103
-13	Rizor	Spreckels	11404	34.81	16.39	176	23.3	93.8	111
-14	97CX01	Spreckels	11253	36.19	15.51	173	8.7	95.1	121
-15	97CX02	Spreckels	11626	38.95	14.93	165	7.1	95.3	157
-16	US H11	Check	8952	31.11	14.39	156	2.1	93.7	119
-17	97CX09	Spreckels	12239	36.92	16.57	184	19.6	93.5	86
-18	7CG7304	Betaseed	10766	37.25	14.46	173	20.0	92.9	159
-19	Beta 4776R	Betaseed	10234	31.86	16.08	179	1.1	93.7	137
-20	HM 3048	Hilleshog	10428	32.13	16.22	177	4.4	94.2	101
-21	SS-NB7R	Spreckels	11845	37.59	15.80	170	4.9	94.7	79
-22	SS-IV2R	Spreckels	11530	37.31	15.45	176	8.7	95.1	90
-23	97CX08	Spreckels	10789	32.02	16.85	183	11.3	94.9	70
-24	4KJ0164	Betaseed	11089	38.64	14.40	180	0.3	93.0	204

TEST B298. AREA 5 CODED NON-RHIZOMANIA YIELD TEST, IMPERIAL VALLEY, 1997-98

(cont.)

Code	Variety	Source	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Beets/ 100' No.	Bolters %	Clean Beets %	NO3-N Mean
CBGA entries (cont.)									
A5N -25	H95786	Spreckels	11442	39.49	14.47	182	7.1	94.3	103
-26	5CG7540	Betaseed	11488	36.06	15.94	177	1.5	93.3	109
-27	SS-778R	Spreckels	11891	38.90	15.32	181	10.7	94.9	96
-28	Beta 4684R	Betaseed	11074	33.85	16.35	181	3.2	96.0	86
-29	Beta 4581	Betaseed	10712	33.22	16.08	179	15.4	94.7	119
USDA Checks									
R778H37	4807(C306/2CMS) x R678		11943	40.48	14.74	164	1.1	94.4	100
R776-89-5H37	4807(C306/2CMS) x R576-89-5		12094	38.73	15.63	176	1.5	94.0	71
Y769H37	4807(C306/2CMS) x Y669		11743	41.60	14.11	173	4.8	93.3	141
Mean			11170.7	36.03	15.55	175.2	7.5	94.4	115.2
LSD (.05)			1090.5	3.33	0.74	10.3	5.1	1.4	56.6
C.V. (%)			9.9	9.38	4.86	6.0	68.9	1.5	49.9
F value			3.4**	5.81**	10.35**	2.8*	13.6**	2.5**	3.9**

TEST B298. AREA 5 CODED NON-RHIZOMANIA YIELD TEST, IMPERIAL VALLEY, 1997-98

(cont.)

Code	Variety	Recover. Sugar lbs/a	Recover. Sugar lbs/t	Recover. Sugar %	Known SugarLoss lbs/a	Sodium ppm	Potassium ppm	NH_2-N ppm	Impur. Value
CBGA entries									
A5N - 1	97CX06	9539	284	90.0	1055	366	2137	398	10400
- 2	Beta 4006R	9866	305	91.5	909	267	1822	412	9406
- 3	SS-781R	9643	260	86.8	1455	404	2530	554	13000
- 4	97CX10	9970	300	90.3	1056	311	2127	447	10657
- 5	97CX07	9518	266	87.1	1400	351	2679	537	13028
- 6	7CG7391	9541	236	83.9	1778	656	2893	561	14853
- 7	97CX04	9674	252	86.6	1471	478	2791	422	12659
- 8	Rival	9783	288	88.3	1275	329	2415	567	12572
- 9	Beta 4035R	10403	288	88.5	1294	312	2462	505	12043
-10	SS-694R	8202	255	86.6	1265	426	2540	537	12943
-11	5KJ0142	11067	305	91.6	1024	296	2031	331	9256
-12	7CG7400	10268	283	87.6	1460	340	2573	597	13293
-13	Rizor	10042	289	88.0	1362	348	2519	577	12996
-14	97CX01	9815	270	86.7	1438	352	2595	603	13448
-15	97CX02	9915	254	84.9	1710	398	2792	669	14728
-16	US H11	7657	246	85.2	1296	381	2594	657	14057
-17	97CX09	10962	296	89.4	1277	262	2387	499	11627
-18	7CG7304	9154	246	85.0	1612	438	2841	599	14324
-19	Beta 4776R	9078	285	88.6	1156	405	2220	534	12044
-20	HM 3048	9248	288	88.5	1180	343	2390	539	12290
-21	SS-NB7R	10354	277	87.5	1491	307	2692	558	13107
-22	SS-IV2R	10087	270	87.4	1443	297	2316	641	12921
-23	97CX08	9749	304	90.3	1040	255	2244	458	10856
-24	4KJ0164	9531	248	85.7	1558	606	2525	518	13352

TEST B298. AREA 5 CODED NON-RHIZOMANIA YIELD TEST, IMPERIAL VALLEY, 1997-98

(cont.)

Code	Variety	Recover. Sugar lbs/a	Recover. Sugar lbs/t	Recover. Sugar %	Known SugarLoss lbs/a	Sodium ppm	Potassium ppm	NH_2-N ppm	Impur. Value
CBGA entries (cont.)									
A5N -25	H95786	10108	256	88.3	1335	387	2525	374	11222
-26	5CG7540	10160	282	88.4	1329	440	2392	499	12255
-27	SS-778R	10515	271	88.4	1377	411	2524	429	11821
-28	Beta 4684R	9861	291	88.9	1213	302	2391	518	11958
-29	Beta 4581	9533	286	88.7	1179	322	2474	483	11897
USDA checks									
A5N -30	R778H37	10280	254	85.9	1663	419	2768	559	13697
-31	R776-89-5H37	10670	276	88.1	1424	373	2588	472	12262
-32	Y769H37	10074	242	85.7	1669	455	2866	479	13306
Mean		9820.8	273.6	87.8	1349.8	376.1	2488.8	516.6	12446.1
LSD (.05)		1052.4	18.5	2.3	247.3	122.5	276.7	122.0	1884.9
C.V. (%)		10.9	6.9	2.7	18.6	33.1	11.3	24.0	15.4
F value		3.3**	9.2**	5.0**	5.8**	4.1**	6.3**	3.4**	4.0**

TEST B698. EVALUATION OF EXPERIMENTAL HYBRIDS UNDER RHIZOMANIA, IMPERIAL VALLEY, 1997-98

48 entries x 8 replications, RCB(E)
1-row plots, 18 ft. long

Planted: September 9, 1997
Harvested: May 14-15, 1998

Variety	Description	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Beets/ 100' No.	Bolters %	Clean Beets %	NO3-N Mean
Checks								
Rizor	9-3-97	10101	30.04	16.82	147	14.1	91.1	49
B4776R	Beta 4776.7033 (9-1-97)	9497	27.46	17.28	163	0.0	91.5	42
SS-781R	9-3-97	8826	27.91	15.82	153	0.6	93.3	45
Self-sterile,O.P. breeding lines								
R576-89-18H50	F92-790-15CMS x R476-89-18	10679	31.40	17.08	148	4.2	92.6	21
Y769H50	F92-790-15CMS x Y669	10275	30.03	17.08	152	8.2	90.3	26
Y774H50	F92-790-15CMS x Y74(C)	10272	31.00	16.58	146	9.9	92.1	42
R776-89-5H50	F92-790-15CMS x R576-89-5	9853	28.96	17.03	142	3.5	91.3	21
R778H50	F92-790-15CMS x R678	9830	29.33	16.83	147	1.8	89.9	34
Y772H50	F92-790-15CMS x RZM Y672	9774	29.18	16.85	147	6.0	91.8	34
Y771H50	F92-790-15CMS x RZM Y671	9459	29.71	15.94	139	7.8	92.4	64
Y773H50	F92-790-15CMS x RZM Y673R	9161	28.77	15.98	143	7.4	92.1	42
C79-# breeding lines								
R779H50	F92-790-15CMS x RZM R679	10067	30.89	16.27	140	13.7	93.0	44
R736H50	F92-790-15CMS x RZM R636	9813	31.93	15.39	151	10.2	90.7	68
R746H50(Iso)	F92-790-15CMS x RZM R646	9140	27.61	16.59	138	3.3	89.5	41
R753H50	F92-790-15CMS x RZM R653	8797	26.47	16.61	139	1.0	90.9	24
R746H50(Sp)	F92-790-15CMS x RZM R646,R653	8688	26.80	16.15	162	2.0	90.4	39
R735H50	F92-790-15CMS x RZM R635	8688	25.66	16.96	131	4.4	89.4	26
Self-fertile,Aa,random-mated populations								
7931H50	F92-790-15CMS x 931(C)	10064	30.19	16.71	155	5.7	90.5	23
7933H50	F92-790-15CMS x 6264-#(C)	9979	29.17	17.13	149	5.3	90.7	15
7926H50	F92-790-15CMS x 926(C)	9926	29.43	16.94	149	11.9	90.5	30
Z731H50	F92-790-15CMS x Z31(C)	9889	30.07	16.43	150	8.2	91.2	51
7924H50	F92-790-15CMS x 924(C)	9243	27.13	16.93	149	6.1	91.0	26
7932CTH50	F92-790-15CMS x 6260-63-#(C)	9219	27.71	16.69	146	13.0	90.7	30
CR711H50	F92-790-15CMS x CR11(C)	9009	27.50	16.42	143	10.1	89.1	33

TEST B698. EVALUATION OF EXPERIMENTAL HYBRIDS UNDER RHIZOMANIA, IMPERIAL VALLEY, 1997-98

(cont.)

Variety	Description	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Beets/ 100' No.	Bolters %	Clean Beets %	NO3-N Mean
S_1 et al. progeny lines from S^f,Aa popns								
7918-21H50	F92-790-15CMS x RZM 6918-21	10838	31.80	17.05	150	0.0	91.7	21
6918-3H50	F92-790-15CMS x RZM 4918-3	10486	31.29	16.81	149	2.3	85.8	15
6918-12H50	F92-790-15CMS x RZM 4918-12	10093	30.14	16.83	149	4.4	90.2	20
6913-70H50	F92-790-15CMS x 5913-70	9608	29.26	16.46	137	11.5	90.2	22
7911-4-10H50	F92-790-15CMS x RZM 6911-4-10	9596	27.96	17.17	147	0.5	86.4	8
Testcrosses to C306/2CMS								
R778H37	4807HO(C306/2CMS) x R678	11022	34.35	15.98	150	0.4	91.2	33
Y769H37	4807HO(C306/2CMS) x Y669	10588	34.86	15.23	150	1.8	90.4	55
Z731H37	4807HO(C306/2CMS) x Z31(C)	10399	32.16	16.25	147	0.8	91.5	39
R776-89-5H37	4807HO(C306/2CMS) x R576-89-5	10153	31.57	16.07	137	0.0	92.0	37
Y774H37	4807HO(C306/2CMS) x Y74(C)	9556	31.07	15.35	151	8.2	90.2	39
Testcrosses to popn-869								
CR711H69	6869aa x CR11(C)	9464	28.99	16.31	140	6.5	91.3	29
R778H69	6869aa x R678	9255	27.98	16.57	137	3.7	91.8	28
Y774H69	6869aa x Y74(C)	9217	28.61	16.08	144	4.6	92.2	44
Y769H69	6869aa x Y669	9067	28.14	16.15	145	1.8	92.6	39
Z731H69	6869aa x Z31(C)	9036	27.51	16.42	141	4.0	89.8	22
7924H69	6869aa x 924(C)	9013	26.87	16.75	146	2.9	89.9	22
R776-89-5H69	6869aa x R576-89-5	8946	26.43	16.94	154	2.3	92.2	28
7926H69	6869aa x 926(C)	8910	27.64	16.14	153	5.0	91.5	36
7931H69	6869aa x 931(C)	8856	26.48	16.74	146	1.9	89.9	12
Testcrosses to 711-4-7mm								
Z731H7	6911-4-7HO x Z31(C)	10429	30.72	17.04	146	22.4	88.4	13
R778H7	6911-4-7HO x R678	8935	26.25	17.00	139	1.5	89.9	9
R776-89-5H7	6911-4-7HO x R576-89-5	8644	25.37	17.05	145	13.2	89.8	16
Y769H7	6911-4-7HO x Y669	8602	26.96	16.00	146	11.9	92.3	27
Testcross to C890-7(SES)								
R778H17M	6817Maa x R678	8560	25.95	16.53	142	1.4	91.8	37

TEST B698. EVALUATION OF EXPERIMENTAL HYBRIDS UNDER RHIZOMANIA, IMPERIAL VALLEY, 1997-98

(cont.)

Variety	Description	Acre Yield		Sucrose	Beets/ 100'	Bolters	Clean Beets	NO3-N
		Sugar Lbs	Beets Tons	%	No.	%	%	Mean
Mean		9573.3	29.01	16.53	146.2	5.7	90.8	31.6
LSD (.05)		1291.1	3.61	0.74	15.0	5.4	2.4	22.7
C.V. (%)		12.9	12.65	4.53	10.4	96.8	2.7	72.9
F value		2.3**	2.82**	3.56**	1.3NS	6.3**	2.8**	2.7**

NOTES: See test B198. Tests B598-B898 were grown under mild rhizomania infested conditions. For the May harvest, few symptoms were evident. For the June harvest, foliar coloration suggested differential effects of rhizomania (efficiency of nitrogen and water uptake). Plant growth and plot uniformity suggested infestation of rhizomania was variable leading to higher CV's.

TEST B798. EVALUATION OF POPULATION HYBRIDS UNDER RHIZOMANIA, IMPERIAL VALLEY, 1997-98

24 entries x 8 replications, RCB(E)
1-row plots, 18 ft. long

Planted: September 9, 1997
Harvested: May 13, 1998

Variety	Description	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Beets/ 100' No.	Bolters %	Clean Beets %	NO3-N Mean
Checks								
Rizor	9-3-97	10465	31.93	16.85	154	17.3	92.8	51
R778H50	F92-790-15CMS x R678	10465	31.79	16.50	143	3.9	91.8	47
R776-89-5H50	F92-790-15CMS x R576-89-5	9578	28.91	16.57	140	4.5	92.8	50
B4776R	Beta 4776.7033 (9-1-97)	9462	28.51	16.59	153	0.0	92.4	81
TC of Progeny Lines from popns								
R778H31-4	6831-4aa x R678	10213	32.22	15.83	142	0.0	93.2	54
R778H59-8	6859-8aa x R678	10033	29.28	17.13	142	0.0	93.0	30
R778H64	5864-14HO x R678	9257	28.94	16.12	133	0.5	94.0	47
R778H93	6891-10HO x R678	9059	28.61	15.91	142	1.6	93.2	52
R776-89-5H27	6831-4HO x R576-89-5	9348	29.35	15.99	138	2.1	92.0	39
R776-89-5H7	6911-4-7HO x R576-89-5	9245	28.39	16.32	133	10.7	90.9	20
R776-89-5H66	4867-1H50 x R576-89-5	9073	27.05	16.78	125	7.2	92.2	25
R776-89-5H10	5911-4H50 x R576-89-5	8640	26.07	16.60	140	8.9	90.1	31
Popn Hybrids								
R776-89-5H69	6869aa x R576-89-5	10389	31.67	16.50	148	1.8	93.1	32
R776-89-5H31	6931aa x R576-89-5	10368	31.18	16.66	139	2.2	92.1	31
R776-89-5H11	5911-4maa x R576-89-5	9227	28.08	16.46	130	3.2	93.7	27
R776-89-5H13	6913-70aa x R576-89-5	8969	29.60	15.20	136	27.2	92.1	56
R778H18	6818maa x R678	11253	33.49	16.81	140	1.5	92.0	24
R778H87	5890aa x R678	9373	28.53	16.43	147	0.0	92.3	28
R778H17M	6817Maa x R678	8953	28.00	15.98	135	1.5	92.3	44
R778H12	6812maa x R678	8142	25.23	16.15	145	13.8	92.5	31

TEST B798. EVALUATION OF POPULATION HYBRIDS UNDER RHIZOMANIA, IMPERIAL VALLEY, 1997-98

(cont.)

Variety	Description	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Beets/ 100' No.	Bolters %	Clean Beets %	NO3-N Mean
Popn Hybrids (cont.)								
R778H34	6834aa x R678	10841	32.22	16.88	151	4.3	92.7	22
R778H33	6833aa x R678	10526	31.95	16.57	140	0.5	93.6	44
R778H38M	6837Maa x R678	9849	29.91	16.45	136	2.2	91.5	33
R778H28	6828aa x R678	9110	27.47	16.58	143	11.8	93.3	19
Mean		9672.1	29.52	16.41	140.6	5.3	92.5	38.2
LSD (.05)		1030.6	3.10	0.67	15.3	5.4	2.3	26.0
C.V. (%)		10.8	10.66	4.16	11.0	104.2	2.5	69.1
F value		4.5**	3.68**	3.00*	1.6*	11.9**	1.2NS	2.5*

NOTES: See tests B198, B498, B598 & B698.

TEST B898. EVALUATION OF PROGENY LINES UNDER RHIZOMANIA, IMPERIAL VALLEY, 1997-98

24 entries x 4 replications, RCB
1-row plots, 18 ft. long

Planted: September 9, 1997
Harvested: May 13, 1998

Variety	Description	Acre Yield		Sucrose	Beets/ 100'	Bolters	Clean Beets	NO3-N
		Sugar Lbs	Beets Tons	%	No.	%	%	Mean
Checks								
R778H50	F92-790-15CMS x R678	10510	33.38	15.72	149	7.6	93.6	80
B4776R	Beta 4776.7033 (9-1-97)	9925	31.34	15.84	150	0.0	94.0	141
Rizor	9-3-97	9765	31.27	15.66	154	17.3	93.3	75
R776-89-5H50	F92-790-15CMS x R576-89-5	9090	29.29	15.57	132	1.1	94.0	100
C76-89-5								
R776-89-5H11-15M	6911-4-15Maa x R576-89-5	10244	35.07	14.63	131	12.3	94.6	84
R776-89-5H7	6911-4-7HO x R576-89-5	9776	31.02	15.74	122	12.3	93.4	49
R776-89-5H11	5911-4maa x R576-89-5	9733	31.68	15.15	124	4.4	94.8	76
R776-89-5H11-1	6911-4-1aa x R576-89-5	8673	27.04	16.06	149	6.9	93.1	46
Topcrosses with C78								
R778H18	6818maa x R678	10617	33.40	15.85	138	6.2	92.9	62
R778H18B-2	6818B-2aa x R678	10090	31.94	15.80	145	2.0	91.3	47
R778H18B-12	6818B-12aa x R678	9836	32.14	15.36	121	6.1	93.5	78
R778H18B-1	6818B-1aa x R678	9017	29.47	15.36	138	2.5	93.0	89
R778H18B-21	6818B-21aa x R678	8719	29.30	14.72	143	1.0	90.6	49
R778H18-2	6818-2aa x R678	10418	32.84	15.90	132	1.0	93.4	32
R778H18-21	6818-21aa x R678	10343	32.42	15.93	132	0.0	93.8	58
R778H18-3	6818-3aa x R678	10248	31.99	16.02	150	0.0	92.1	47
R778H18-6	6818-6aa x R678	10178	31.95	15.95	128	0.0	93.2	33

TEST B898. EVALUATION OF PROGENY LINES UNDER RHIZOMANIA, IMPERIAL VALLEY, 1997-98

(cont.)

Variety	Description	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Beets/ 100' No.	Bolters %	Clean Beets %	NO3-N Mean
Topcrosses with C78 (cont.)								
R778H18-15	6818-15aa x R678	9991	31.46	15.86	132	4.3	93.7	60
R778H18-23	6818-23aa x R678	9813	30.94	15.87	145	3.0	92.8	40
R778H18-7	6818-7aa x R678	9769	30.26	16.14	131	0.0	92.8	58
R778H18-14	6818-14aa x R678	9622	30.82	15.65	146	0.0	92.2	59
R778H18-12	6818-12aa x R678	9297	28.56	16.27	140	5.8	92.5	35
R778H18-1	6818-1aa x R678	9092	28.31	16.02	135	0.9	92.1	58
R778H18-11	6818-11aa x R678	9007	29.34	15.41	124	0.0	90.6	59
Mean		9740.6	31.05	15.69	137.0	4.0	93.0	63.1
LSD (.05)		2011.9	5.97	1.16	28.2	6.4	2.5	50.6
C.V. (%)		14.6	13.63	5.22	14.6	114.0	1.9	56.9
F value		0.6NS	0.76NS	1.00NS	1.0NS	4.4**	1.5NS	1.9*

NOTES: See tests B198, B498 & B698. 6818 = C890-8 ≈ C790 with rhizomania resistance from R22(C51). 6818=# = monogerm, S_1 progeny families being evaluated for SY GCA in test B898 and for resistance to rhizomania under high temperature conditions in test B1198 to be harvested in July.

TEST B598. AREA 5 CODED RHIZOMANIA YIELD TEST, IMPERIAL VALLEY, 1997-98

36 entries x 8 reps., RCB
1-row plots, 27 ft. long

Planted: September 9, 1997
Harvested: June 4-5, 1998

Code No.	Variety	Source	Acre Yield		Sucrose	Beets/ 100'	Bolters	Clean Beets	NO3-N	Yellows
			Sugar Lbs	Beets Tons	%	No.	%	%	Mean	Score
CBGA entries										
A5R - 1	5KJ0142	Betaseed	11442	33.60	17.03	173	0.9	94.6	49	7.5
- 2	Beta 4776R	Betaseed	9961	29.98	16.66	156	3.6	92.8	104	5.9
- 3	US H11	Check	6757	22.71	14.77	144	0.0	89.7	45	5.5
- 4	SS-IV2R	Spreckels	10327	33.43	15.49	161	6.1	92.2	88	2.9
- 5	97CX08	Spreckels	9574	28.46	16.90	154	6.9	92.8	98	4.8
- 6	Beta 4684R	Betaseed	9914	29.47	16.84	160	2.7	93.0	48	3.4
- 7	SS-IV2	Check	9490	31.45	15.04	159	0.6	89.7	40	5.8
- 8	Beta 4035R	Betaseed	10832	32.12	16.86	163	1.4	91.3	44	3.9
- 9	SS-NB7R	Spreckels	9680	29.58	16.33	152	2.1	89.8	39	3.6
-10	SS-778R	Spreckels	10146	33.43	15.15	147	4.7	92.6	60	5.3
-11	7CG7400	Betaseed	9311	28.26	16.55	157	0.7	88.7	76	4.6
-12	97CX09	Spreckels	10745	31.24	17.17	166	11.8	91.8	55	3.9
-13	97CX04	Spreckels	10800	35.57	15.23	162	8.8	91.3	66	4.4
-14	4KJ0164	Betaseed	9509	31.55	15.09	153	0.4	91.1	147	5.1
-15	Beta 4006R	Betaseed	9806	29.16	16.84	166	1.7	91.4	31	4.9
-16	5CG7540	Betaseed	10056	31.90	15.79	157	1.8	90.0	109	4.6
-17	97CX07	Spreckels	10618	33.95	15.68	152	10.9	92.6	99	3.8
-18	HM 3048	Hilleshog	8702	26.25	16.59	164	5.9	90.5	51	6.3
-19	97CX01	Spreckels	9922	30.95	16.03	151	2.8	91.6	28	3.6
-20	HM 3013	Check	8507	27.46	15.46	151	0.6	91.3	23	8.0
-21	97CX06	Spreckels	9219	28.54	16.12	141	3.5	89.6	51	3.4
-22	Beta 4684	Check	9167	28.67	15.97	153	1.4	91.6	21	5.1
-23	Rizor	Spreckels	10234	30.17	16.96	171	14.0	88.4	37	3.4
-24	7CG7391	Betaseed	10502	35.05	14.96	164	2.0	90.3	145	7.1

TEST B598. AREA 5 CODED RHIZOMANIA YIELD TEST, IMPERIAL VALLEY, 1997-98

(cont.)

Code No.	Variety	Source	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Beets/ 100' No.	Bolters %	Clean Beets %	NO3-N Mean	Yellows Score
CBGA entries (cont.)										
A5R -25	97CX02	Spreckels	10436	33.36	15.65	132	5.3	92.8	51	2.4
-26	H95786	Spreckels	10321	34.92	14.77	165	2.0	91.0	48	6.1
-27	Rival	Spreckels	9057	26.62	17.02	166	14.2	90.1	37	4.8
-28	SS-781R	Spreckels	10216	32.44	15.76	149	2.4	92.4	36	3.3
-29	97CX10	Spreckels	10090	29.63	17.00	165	12.4	90.5	50	5.0
-30	Rhizoguard	Spreckels	8203	25.29	16.22	158	0.3	93.3	34	4.6
-31	Beta 4581	Betaseed	10381	30.09	17.25	152	13.6	90.3	39	4.9
-32	7CG7304	Betaseed	11013	36.87	14.93	152	20.2	89.8	88	4.1
-33	SS-694R	Spreckels	8740	27.14	16.08	161	7.1	90.7	37	4.5
USDA entries										
R776-89-5H37	4807(C306/2CMS) x R576-89-5		11078	34.12	16.36	147	1.5	89.6	25	4.6
Y774H37	4807(C306/2CMS) x Y74(C)		9890	35.78	13.82	157	5.0	86.9	56	5.3
Y769H69	6869aa x Y669		10186	32.35	15.88	161	5.5	89.5	50	4.1
Mean			9851.4	30.87	16.00	156.8	5.2	91.0	58.4	4.7
LSD (.05)			1189.4	3.69	0.76	14.4	4.5	2.4	39.5	1.1
C.V. (%)			12.3	12.12	4.82	9.4	88.5	2.7	68.7	23.1
F value			4.6**	5.99**	9.62**	2.7**	9.8**	3.4**	5.0**	10.5**

NOTES: Test appeared to be 100% infected with whitefly vectored lettuce chlorosis virus (LCV). Based upon foliar color and symptoms, differences in reaction to LCV may have occurred, but symptom expression was confounded by rhizomania, low nitrogen status, insect feeding, and powdery mildew. Powdery mildew developed late. Rhizomania, root symptoms were mild. Infection and effects of rhizomania appeared to be variable across this test leading to increased variability and CV's.

Test was scored for foliar yellowing on 6-2-98. Yellowing appeared to be primarily due to LCV, but yellowing may have been enhanced by rhizomania, insect feeding, powdery mildew, plant age, low nitrogen status, etc. At all observation times in January, April, May and June, entries A5R-1 and A5R-20 were the most yellowed. In April, entries A5R-9, -13, -15, & -32 were the greenest.

TEST B598. AREA 5 CODED RHIZOMANIA YIELD TEST, IMPERIAL VALLEY, 1997-98

(cont.)

Code	Variety	Recover. Sugar lbs/a	Recover. Sugar lbs/t	Recover. Sugar %	Known SugarLoss lbs/a	Sodium ppm	Potassium ppm	NH_2-N ppm	Impur. Value
CBGA entries									
A5R - 1	5KJ0142	10558	314	92.3	884	329	1880	304	8741
- 2	Beta 4776R	9049	303	91.0	911	465	1837	398	10006
- 3	US H11	6043	265	89.6	714	400	2227	349	10283
- 4	SS-IV2R	9045	272	87.7	1281	374	2298	589	12647
- 5	97CX08	8586	304	89.8	988	451	2196	456	11398
- 6	Beta 4684R	8995	306	90.9	919	318	2078	410	10201
- 7	SS-IV2	8483	269	89.5	1007	426	2101	399	10534
- 8	Beta 4035R	9916	309	91.6	916	349	2044	320	9374
- 9	SS-NB7R	8645	292	89.5	1035	328	2345	476	11530
-10	SS-778R	8993	269	88.7	1152	424	2435	402	11390
-11	7CG7400	8303	296	89.5	1007	460	2321	436	11550
-12	97CX09	9714	310	90.3	1031	337	2221	449	11001
-13	97CX04	9636	272	89.1	1164	433	2321	370	10834
-14	4KJ0164	8305	264	87.4	1204	648	2360	476	12693
-15	Beta 4006R	9061	311	92.4	745	318	1559	372	8538
-16	5CG7540	8866	279	88.2	1190	586	2334	470	12348
-17	97CX07	9365	277	88.2	1253	334	2330	549	12211
-18	HM 3048	7891	302	90.9	811	324	2033	406	10072
-19	97CX01	8958	290	90.4	964	322	2167	394	10289
-20	HM 3013	7799	284	91.8	708	402	1969	222	8440
-21	97CX06	8352	293	90.8	867	361	1992	388	9926
-22	Beta 4684	8394	293	91.6	773	329	1922	312	8917
-23	Rizor	9338	309	91.2	896	271	2062	403	9929
-24	7CG7391	9131	261	87.0	1371	702	2617	411	12902

TEST B598. AREA 5 CODED RHIZOMANIA YIELD TEST, IMPERIAL VALLEY, 1997-98

(cont.)

Code	Variety	Recover. Sugar lbs/a	Recover. Sugar lbs/t	Recover. Sugar %	Known SugarLoss lbs/a	Sodium ppm	Potassium ppm	NH_2-N ppm	Impur. Value
CBGA entries (cont.)									
A5R -25	97CX02	9344	280	89.6	1092	341	2311	411	10870
-26	H95786	9244	265	89.6	1077	438	2405	276	10168
-27	Rival	8231	310	91.1	826	289	2059	414	10089
-28	SS-781R	9090	281	89.2	1126	353	2244	475	11361
-29	97CX10	9155	309	90.8	935	315	2089	434	10451
-30	Rhizoguard	7502	297	91.5	701	342	2015	309	9163
-31	Beta 4581	9416	313	90.7	964	261	2141	466	10698
-32	7CG7304	9517	258	86.4	1496	476	2825	502	13494
-33	SS-694R	7867	290	90.3	873	367	2129	402	10421
USDA entries									
A5R -34	R776-89-5H37	10041	297	90.8	1037	429	2115	336	9981
-35	Y774H37	8674	243	87.8	1216	554	2442	336	11231
-36	Y769H69	9180	287	90.2	1006	464	2129	347	10243
Mean		8849.1	288.1	89.9	1002.3	397.6	2180.6	400.7	10649.6
LSD (.05)		1068.6	17.2	1.7	217.3	107.2	230.1	111.2	1542.0
C.V. (%)		12.3	6.1	1.9	22.0	27.4	10.7	28.2	14.7
F value		4.5**	9.3**	6.1**	5.9**	6.8**	7.7**	3.5**	5.0**

NOTES: Test appeared t be 100% infected with whitefly vectored lettuce chlorosisvirus (LCV). Based upon foliar color and symptoms, differences in reaction to LCV may have occurred, but symptom expression was confounded by rhizomania, low nitrogen status, insect feeding, and powdery mildew. Powdery mildew developed late. Rhizomania, root symptoms were mild. Infection and effects of rhizomania appeared to be variable across this test leading to increased variability and CV's.

Test was scored for foliar yellowing on 6-2-98. Yellowing appeared to be primarily due to LCV, but yellowing may have been enhanced by rhizomania, insect feeding, powdery mildew, plant age, low nitrogen status, etc. At all observation times in January, April, May and June, entries A5R-1 and A5R-20 were the most yellowed. In April, entries A5R-9, -13, -15, & -32 were the greenest.

TEST B998. AREA 5 CODED RHIZOMANIA OBSERVATION TEST UNDER SEVERE RHIZOMANIA, IMPERIAL VALLEY, CA., 1997-98

36 entries x 4 reps., sequential
1-row plots, 18 ft. long

Planted: September 10, 1997
Not harvested for yield

Code	Variety	Source	Stand Count	14 July 1998 Plants at Harvest	14 July 1998 Dead Plants	14 July 1998 RZM	02 June Yellows
			No.	No.	%	Score	Score
1	5KJ0142	Betaseed	29	27	2.7	0.5	6.0
2	Beta 4776R	Betaseed	28	26	2.1	0.5	6.5
3	US H11	Check	29	23	26.6	2.0	5.5
4	SS-IV2R	Spreckels	30	25	8.0	1.5	4.3
5	97CX08	Spreckels	30	25	4.2	1.3	5.3
6	Beta 4684R	Betaseed	29	28	4.4	1.0	4.3
7	SS-IV2	Check	31	26	9.7	1.5	7.3
8	Beta 4035R	Betaseed	28	25	0.9	1.0	5.3
9	SS-NB7R	Spreckels	29	25	2.1	0.5	4.8
10	SS-778R	Spreckels	27	24	5.1	1.3	6.0
11	7CG7400	Betaseed	29	25	2.1	1.0	6.0
12	97CX09	Spreckels	29	25	7.4	1.5	3.8
13	97CX04	Spreckels	30	24	6.6	1.3	5.3
14	4KJ0164	Betaseed	29	27	7.1	0.8	7.0
15	Beta 4006R	Betaseed	29	27	13.9	1.5	6.5
16	5CG7540	Betaseed	31	26	1.0	0.8	5.8
17	97CX07	Spreckels	31	27	0.8	0.5	5.8
18	HM 3048	Hilleshog	30	26	3.6	1.5	7.0
19	97CX01	Spreckels	28	23	2.1	1.0	5.8
20	HM 3013	Check	26	22	23.2	1.8	8.3
21	97CX06	Spreckels	29	24	2.9	0.5	5.5
22	Beta 4684	Check	29	26	18.9	1.8	5.8
23	Rizor	Spreckels	30	28	1.8	1.0	5.0
24	7CG7391	Betaseed	31	29	2.6	1.0	7.8
25	97CX02	Spreckels	28	23	3.3	1.3	5.0
26	H95786	Spreckels	29	25	5.9	1.3	5.5

TEST B998. AREA 5 CODED RHIZOMANIA OBSERVATION TEST UNDER SEVERE RHIZOMANIA, IMPERIAL VALLEY, CA., 1997-98

(cont.)

Code	Variety	Source	Stand Count	14 July 1998 Plants at Harvest	14 July 1998 Dead Plants	14 July 1998 RZM	02 June Yellows
			No.	No.	%	Score	Score
27	Rival	Spreckels	31	28	1.6	1.3	5.0
28	SS-781R	Spreckels	29	24	8.6	1.5	5.3
29	97CX10	Spreckels	30	26	10.4	1.5	6.0
30	Rhizoguard	Spreckels	30	27	9.9	1.8	6.8
31	Beta 4581	Betaseed	31	25	6.6	1.8	7.5
32	7CG7304	Betaseed	30	24	2.2	0.3	4.8
33	SS-694R	Spreckels	29	26	3.0	0.8	5.5
34	7926H50	USDA	29	23	13.1	1.5	5.5
35	Y774H50	USDA	30	26	6.7	0.8	5.5
36	R746H50	USDA	28	21	9.6	0.5	4.5
Mean			29.1	25.3	6.7	1.1	5.7
LSD (.05)			4.3	3.9	10.8	1.1	1.8
C.V. (%)			10.5	11.1	115.1	70.6	22.3
F value			0.6NS	1.6*	2.5**	1.3NS	2.5**

Test was scored for foliar yellowing on 6-2-98. Yellowing appeared to be primarily due to LCV, but yellowing may have been enhanced by rhizomania, insect feeding, powdery mildew, plant age, low nitrogen status, etc.

Notes for B998, B1098, B1198: RZM visually scored on 14 July 1998 from 0 to 5, where 0 = 100% alive and vigorous plot; 1 = good vigor and survival; 2 = reduced vigor and fewer alive; 3 = intermediate vigor and survival; 4 = poor, low vigor, most plants dead; 5 = 100% of plants dead.

% Dead Plants based upon actual counts of living vs. dead plants 14 July 98, where living = any plant with green. Stand counts in October 97 shortly after thinning.

Usually US H11 and other fully rhizomania susceptible entries completely collapse in the high temperatures when infected with rhizomania. In 1998 El Niño conditions of more moderate temperatures in Imperial Valley, rhizomania infected plants continued to live.

TEST B1098. EVALUATION OF LINES UNDER HIGH TEMPERATURE, RHIZOMANIA CONDITIONS
IN A LATE HARVEST (GERMPLASM FROM R22,C51), IMPERIAL VALLEY, CA., 1997-98

72 entries x 4 replications, sequential
1-row plots, 18 ft. long

Planted: September 10, 1997
Not harvested for yield

Variety	Description	Stand Count	14 June 1998 Plants at Harvest	14 June 1998 Dead Plants	14 June 1998 RZM	13 May Bolting
		No.	No.	%	Score	Score
SS-781R	9-3-97	30	25	14.4	1.8	0.0
B4776R	9-1-97	28	25	8.3	2.0	0.0
Rival	HH103, 1997	29	29	5.3	2.0	1.7
Rizor	9-3-97	30	28	8.9	2.3	0.0
US H11	1997	28	24	33.0	3.5	0.0
R522(Sp)	RZM-%S R322R4,…(C51)	27	23	1.2	0.3	26.9
R726	RZM-ER R526	28	22	1.3	0.5	26.8
R727A	U86-37 x RZM *Bvm*-UK	27	23	10.4	1.0	48.3
R639	RZM R539 (C37R,quant.)	24	22	6.8	2.0	2.4
Y768	RZM-ER Y568	24	24	13.7	2.0	0.0
Y769(Iso)	RZM Y569	24	22	12.5	1.8	1.0
Y769(Sp)	Inc. Y669	27	24	9.0	2.0	1.3
R778(Iso)	RZM-ER R578,/2,%	27	25	7.2	1.5	3.0
R778%	RZM-ER-%S R578	27	27	9.5	1.8	0.9
R780(Iso)	RZM-ER R580,NB,%	24	23	4.5	1.5	0.0
R780/2	RZM-ER R580-#	28	27	7.3	1.5	0.0
R780-45	RZM-ER R580-45	27	27	16.7	2.3	0.0
R770	RZM-ER R570	27	24	12.1	1.8	2.1
R776	RZM-ER R576	28	25	22.2	2.0	0.0
R781	RZM-ER R581	23	21	18.2	2.5	0.0
R781-43	RZM-ER R581-43	25	22	20.3	2.0	0.0
R776-89-5	Inc. R576-89-5	27	24	29.7	2.5	0.0
R740	RZM-ER R540%,…	25	34	26.3	1.8	9.0
R735	RZM-R635 (C79-7,SES)	21	19	13.0	2.0	0.0

TEST B1098. EVALUATION OF LINES UNDER HIGH TEMPERATURE, RHIZOMANIA CONDITIONS IN A LATE HARVEST (GERMPLASM FROM R22,C51), IMPERIAL VALLEY, CA., 1997-98

(cont.)

Variety	Description	Stand Count	14 June 1998 Plants at Harvest	14 June 1998 Dead Plants	14 June 1998 RZM	13 May Bolting
		No.	No.	%	Score	Score
R724	RZM R824 (C79-2,WB41)	26	23	9.4	1.5	2.1
R725	RZM R425,R525 (C79-3,WB42)	27	26	8.6	1.5	0.0
97-C37	Inc. U86-37	22	20	25.3	2.3	0.0
R779	RZM R679 (C79-1,Rz)	25	23	16.3	2.3	0.0
R736	RZM R636 (C79-8,R22)	25	20	8.1	0.8	1.1
R746	RZM R646	24	22	6.7	1.5	0.0
R753	RZM R653	26	21	10.8	2.0	0.0
R746(Sp)	Inc. RZM R646,R653	23	21	8.5	1.5	0.0
R753(Sp)	Inc. R653,R646	24	21	13.1	1.8	0.0
R754(Sp)	U86-37 x RZM R646,R653	26	24	36.3	3.0	0.0
US H11	1997	26	24	36.3	3.0	0.0
R522(Sp)	RZM-%S R322R4,…(C51)	27	22	1.1	0.8	30.4
Y766	RZM-ER Y566	27	23	3.1	1.0	0.0
Y767	RZM-ER Y567	27	26	1.9	1.3	2.0
Y767(Sp)	RZM Y667,…	26	24	5.4	0.8	6.0
Y771	RZM Y671	27	26	11.4	1.8	5.2
Y772	RZM Y672	25	25	1.0	1.3	1.0
Y772(Sp)	RZM Y672,…	29	27	7.4	1.3	0.0
Y773	RZM Y673R	23	23	7.9	1.8	1.0
Y773(Sp)	RZM Y673,…	27	24	6.3	1.0	1.0
Y775	Y-Rrr(C) x Y74(C)	28	23	11.0	2.0	0.0
Y765	RZM-ER Y565	28	25	8.9	1.0	0.0
N724	Inc. N623,N624(galls)	26	23	27.4	2.8	5.1
CR711	RZM R609,R610,…aa x CR11(C)	27	26	13.0	2.5	0.0

TEST B1098. EVALUATION OF LINES UNDER HIGH TEMPERATURE, RHIZOMANIA CONDITIONS IN A LATE HARVEST (GERMPLASM FROM R22,C51), IMPERIAL VALLEY, CA., 1997-98

(cont.)

Variety	Description	Stand Count	14 June 1998 Plants at Harvest	14 June 1998 Dead Plants	14 June 1998 RZM	13 May Bolting
		No.	No.	%	Score	Score
Z725(C)	Z725-Z730-#(C)aa x A	26	25	14.7	2.3	1.1
Z731	6931aa x Z31(C)	27	26	10.5	2.0	0.0
7747	Inc. 5747(A,aa)	24	22	25.9	3.0	0.0
7931	6931aa x 931(C)	29	27	11.2	2.5	1.9
7926	6931aa x 926(C)	29	26	11.2	2.0	2.1
7927(Sp)	6926,6927aa x 926(C)	29	25	3.0	1.5	2.9
7927(Iso)	RZM-ER 5921H18	28	25	4.7	1.0	4.5
7920NB	NB-RZM 5920	24	23	16.2	2.0	0.0
7923	RZM-ER 5922,5923	26	24	4.3	1.3	3.4
7932CT	Inc. 6260-63-#(C)	28	26	30.3	2.8	0.0
7933	Inc. 6264-#(C)	26	23	28.3	2.8	1.0
7924	6924,29,30aa x 924(C)(tagged)	28	26	32.8	2.8	0.9
US H11	1997	26	24	44.3	2.5	1.0
R522(Sp)	RZM-%S R322R4,…(C51)	25	23	2.1	1.0	28.1
7818m(Sp)	RZM 6818maa x 848(C)	27	25	21.8	2.3	0.0
7818%M	RZM-ER 5818	26	23	31.9	2.3	6.1
7818/2M	RZM 6818	25	24	23.6	2.5	1.1
7818T-O	T-O 6818B-#(C),…	30	24	27.5	2.3	0.0
7838m	6828…aa x 838(C)	28	27	20.1	3.0	0.0
7835m	6833…aa x 835(C)	30	30	15.1	2.8	0.0
7848	0790aa x 848(C)	29	26	31.0	2.8	0.0
7810NBM	NB-RZM 5810M	29	25	13.4	2.8	0.0
7869NBm	NB-RZM 5869m	31	29	12.5	2.5	0.0
7890	RZM-ER 5890	26	23	17.6	2.5	0.0
Mean		26.4	24.3	14.6	1.9	3.2
LSD (.05)		4.5	6.0	14.3	0.8	7.0
C.V. (%)		12.2	17.6	70.2	31.1	155.8
F value		1.7**	1.3NS	3.9**	5.2**	11.2**

TEST B1198. EVALUATION OF TESTCROSSES AND MONOGERM LINES FOR C51(R22) TYPE RESISTANCE IN LATE HARVEST CONDITIONS, IMPERIAL VALLEY, CA., 1997-98

48 entries x 2 reps, sequential
1-row plots, 18 ft. long

Planted: September 10, 1997
Not harvested for yield

Variety	Description	Stand Count	14 July 1998 Plants at Harvest	14 July 1998 Dead Plants	05/13 RZM	07/14 RZM	RZM	13 May Bolting
		No.	No.	%	Score	Score	Mean	%
US H11	1997	27	26	36.1	3.5	2.5	3.0	1.6
Y774H50	F92-790-15CMS x Y74(C)	23	21	23.8	2.5	1.5	2.0	0.0
R778(Sp)	Inc. R678(Iso)	27	26	33.4	3.5	3.0	3.3	0.0
R778H12M	6812maa x R678	29	28	19.7	3.5	2.0	2.8	0.0
R778H17M	6817maa x R678	24	22	20.6	3.5	2.5	3.0	0.0
R778H17-1	6817-1aa x R678	23	22	12.6	3.0	2.0	2.5	0.0
R778H17-2	6817-2aa x R678	31	29	26.3	3.5	2.0	2.8	0.0
R778H17-3	6817-3aa x R678	28	24	20.9	2.5	2.0	2.3	0.0
R778H17-4	6817-4aa x R678	26	23	23.2	3.5	2.5	3.0	0.0
R778H17-5	6817-5aa x R678	29	26	31.5	3.0	2.0	2.5	0.0
R778H17-6	6817-6aa x R678	26	27	28.7	4.0	3.0	3.5	0.0
R778H17-12	6817-12aa x R678	28	28	26.0	4.0	3.0	3.5	0.0
R778H17-13	;6817-13aa x R678	29	29	15.2	5.0	2.5	3.8	0.0
R778H18M	6818-maa x R678	26	28	13.5	3.5	2.0	2.8	0.0
R778H18-1	6818-1aa x R678	26	24	19.0	3.5	2.0	2.8	0.0
R778H18-2	6818-2aa x R678	29	28	13.7	3.5	2.0	2.8	0.0
R778H18-3m	6818-3aa x R678	29	26	24.5	3.5	2.5	3.0	0.0
R778H18-5	6818-5aa x R678	25	24	20.5	4.0	2.5	3.3	0.0
R778H18-6	6818-6aa x R678	30	29	12.6	3.5	2.0	2.8	0.0
R778H18-7	6818-7aa x R678	27	24	18.8	3.5	2.0	2.8	0.0
R778-18-11	6818-11aa x R678	26	22	22.7	4.0	2.5	3.3	0.0
R778H18-12	6818-12aa x R678	30	29	12.1	3.5	1.5	2.5	0.0
R778H18-14	6818-14aa x R678	28	27	22.2	4.5	2.0	3.3	0.0
R778H18-15	6818-15aa x R678	29	27	16.5	3.5	1.5	2.5	0.0

TEST B1198. EVALUATION OF TESTCROSSES AND MONOGERM LINES FOR C51(R22) TYPE RESISTANCE IN LATE HARVEST CONDITIONS, IMPERIAL VALLEY, CA., 1997-98

(cont.)

Variety	Description	14 July 1998 Stand Count	14 July 1998 Plants at Harvest	14 July 1998 Dead Plants	05/13 RZM	07/14 RZM	RZM	13 May Bolting
		No.	No.	%	Score	Score	Mean	%
R778H18-21	6818-21aa x R678	27	25	16.0	3.0	2.0	2.5	0.0
R778H18-23	6818-23aa x R678	28	26	13.9	4.0	2.0	3.0	0.0
R778H18-24	6818-24aa x R678	30	30	10.5	3.5	1.5	2.5	0.0
R778H18B-1	6818B-1aa x R678	26	21	13.9	1.5	1.5	1.5	2.5
R778H18B-2	6818B-2aa x R678	28	27	14.3	2.5	2.0	2.3	0.0
R778H18B-12	6818B-12aa x R678	29	28	27.5	3.5	2.0	2.8	0.0
R778H18B-13	6818B-13aa x R678	33	27	17.6	3.5	2.0	2.8	0.0
R778H18B-15	6818B-15aa x R678	28	27	28.0	3.5	2.0	2.8	0.0
R778H18B-21	6818B-21aa x R678	29	30	5.4	1.5	0.5	1.0	0.0
7818(Sp)m	RZM 6818maa x 848(C)	27	26	15.7	3.5	2.0	2.8	0.0
7818%M	RZM-ER 5818 (C890-8,R22)	28	24	21.6	3.0	1.5	2.3	8.3
7818T-O	T-O 6818-#(C)	24	23	31.2	3.0	2.5	2.8	0.0
7818-4	Inc. 6818B-4mm	23	23	70.4	4.5	4.0	4.3	0.0
7818-14	T-O 6818B-14mm	27	25	41.1	4.5	3.5	4.0	0.0
7818-22	Inc. 6818B-22mm	27	24	36.8	5.0	3.5	4.3	0.0
7818-23	Inc. 6818B-23mm	21	20	55.0	5.0	3.5	4.3	0.0
7812M	RZM 6812M,m(C890-2/3,WB41,42)	28	25	50.0	4.5	3.5	4.0	0.0
7814M	RZM 6814M,m(C890-4,PI07)	25	24	23.2	5.0	3.0	4.0	0.0
7815M	RZM 6815M,m(C890-5,R04)	27	26	21.6	3.0	2.0	2.5	0.0
7816M	RZM 6816M,m(C890-6,R05)	27	26	35.2	3.5	3.0	3.3	0.0
7817%	RZM-ER 5817(C890-7,SES)	23	23	27.1	4.0	2.0	3.0	0.0
7819M	RZM 6819M,m(C890-9,WB51)	25	25	60.1	4.5	3.5	4.0	0.0
7820M	RZM 6820M,m(C890-10,WB169)	27	23	24.0	3.0	2.5	2.8	0.0
7821	RZM 6812M,m(C890-11,WB258)	24	20	44.8	5.0	3.5	4.3	0.0
Mean		26.8	25.0	25.4	3.6	2.3	3.0	0.3
LSD (.05)		5.2	6.9	28.3	1.8	1.1	1.1	3.6
C.V. (%)		9.8	13.7	55.4	24.6	23.0	18.6	689.3
F value		1.6NS	1.2NS	1.8*	1.6*	3.4**	3.2**	1.0NS

CURLY TOP EVALUATION, SALINAS ENTRIES, KIMBERLY, ID., 1998

180 entries x 3 replications
2-row plots, 12 ft. long

Planted:
Not harvested for yield

Variety	Description	Stand Count No.	CT 08/98	CT 09/98
Hybrids				
US H11	F82-546H3 x C36, 111102	27	2.0	3.0
WS-PM9	HM-WS-PM9, 4-18-95	29	2.3	3.0
B4776R	4776R.7653, 3-27-98	29	3.7	4.0
B4035R	Betaseed, 7-10-97	31	3.3	4.0
SS-NB7R	Spreckels 173404, 3-3-98	26	3.3	3.3
Rizor	HH108, 9-3-97	28	3.7	4.0
Monohikari	Seedex, 2-18-97	30	4.0	5.7
7932CT	Inc. 6260…6263(A,aa)CTR	26	2.7	3.3
R778H8	F82-546H3 x R678	25	2.3	3.0
R778H50	C790-15CMS x R678	27	3.0	3.7
R778H7	6911-4-7HO x R678	21	3.0	3.7
R778H17M	6817aa (C890-7) x R678	27	2.7	3.0
R778H18	6818aa (C890-8) x R678	25	2.7	3.3
R778H28M	6828aa x R678	26	2.7	3.3
R778H33	6833aa x R678	21	3.0	3.7
R778H33%	6833%aa x R678	22	3.7	4.0
R778H34	6834%aa x R678	24	2.7	3.3
R778H38M	6837aa x R678	23	3.0	3.7
R778H37	4807HO (C306/2CMS) x R678	25	2.7	3.7
R778H69	6869aa x R678	26	3.0	3.3
R778H87	5890aa (C890-1Rz) x R678	21	3.0	3.3
R778H31-4	6831-4aa (C831-4) x R678	21	3.0	3.7
US H11	111102	27	2.7	3.3
WS-PM9	HM-WS-PM9, 4-18-95	26	2.7	3.3
R746H8	F82-546H3 x RZM R646,R653	23	2.7	3.7
R746H50	C790-15CMS x RZM R646,R653	22	3.0	3.3
Y774H50	C790-15CMS x Y74(C)	26	3.7	3.7
Y769H8	F82-546H3 x Y669	25	3.3	3.7
Y769H7	6911-4-7HO x Y669	22	3.3	4.0
Y769H39	91-762-17CMS x Y669	23	3.0	3.3
Y769H37	4807HO (C306/2CMS) x Y669	22	3.0	3.3
Y769H50	C790-15CMS x Y669	23	2.7	3.3
Y769H69	6869aa x Y669	24	3.0	3.7
R776-89-5H8	F82-546H3 x R576-89-5	26	2.7	3.3
R776-89-5H7	6911-4-7HO x R576-89-5	24	3.3	3.7
R776-89-5H27	6831-4HO x R576-89-5	21	4.0	4.0

CURLY TOP EVALUATION, SALINAS ENTRIES, KIMBERLY, ID., 1998

(cont.)

Variety	Description	Stand Count No.	CT 08/98	CT 09/98
Hybrids (cont.)				
R776-89-5H37	4807HO (C306/2CMS) x R576-89-5	24	3.3	3.7
R776-89-5H39	91-762-17CMS x R576-89-5	24	3.0	3.3
R776-89-5H50	C790-15CMS x R576-89-5	25	3.3	3.7
R776-89-5H66	4867-1H50 x R576-89-5	21	3.0	3.3
R776-89-5H69	6869aa x R576-89-5	26	3.3	3.7
7931H37	4807HO (C306/2CMS) x 931(C)	24	3.3	3.3
7931H50	C790-15CMS x 931(C)	24	3.0	3.0
7931H69	6869aa x 931(C)	25	3.0	3.3
7924H50	C790-15CMS x 924(C)	25	3.3	3.7
7926H50	C790-15CMS x 926(C)	18	3.0	3.0
Z731H7	6911-4-7HO x Z31(C)	23	2.3	3.3
Z731H41	6831-4HO (C831-4CMS) x Z31(C)	21	2.7	3.3
Z731H50	C790-15CMS x Z31(C)	22	2.7	3.3
CR711H50	C790-15CMS x CR11(C)(CR09/10)	24	3.0	3.3
R709-1H50	C790-15CMS x CR-RZM R509A-1	26	2.7	3.3
R709-9H50	C790-15CMS x CR-RZM R509A-9	25	2.7	3.3
R710H50	C790-15CMS x CR-RZM R509,R510	26	2.7	3.0
R710-10H50	C790-15CMS x CR-RZM R510A-10	24	2.7	3.3
R710-14H50	C790-15CMS x CR-RZM R510A-14	27	3.0	4.0
US H11	111102	27	2.7	3.7
WS-PM9	HM-WS-PM9, 4-18-95	27	2.3	3.0
Monohikari	Seedex, 2-18-97	27	4.3	5.3
Multigerm, O.P. Lines				
97SP22-0	Inc. SP7622-0	27	4.0	5.3
97-US22/3	Inc. Y009 (US22/3)	26	2.7	3.3
97-US75	Inc. 268 (US75)	26	2.7	3.7
97-C37	C37, 86443	27	3.3	3.7
U86-37	Inc. U86-37 (C37)	17	3.7	3.7
98-83-161	PX of CTR,MM,O.P.	18	3.7	4.0
98-83-174	PX of CTR,MM,O.P.	9	2.7	3.0
98-83-181	PX of CTR,MM,O.P.	2	2.0	2.3
98-85-243	PX of CTR,MM,O.P.	0	1.3	1.3
98-85-278	PX of CTR,MM,O.P.	17	4.0	4.0
90-CT01	MM,O.P.,CTR	21	2.7	3.3
90-CT02	MM,O.P.,CTR	19	2.3	3.3
R639	RZM R539 (C39R)	23	3.3	3.7
R647	RZM R547 (C47R)	21	3.7	4.0

CURLY TOP EVALUATION, SALINAS ENTRIES, KIMBERLY, ID., 1998

(cont.)

Variety	Description	Stand Count	CT	CT
		No.	08/98	09/98
Multigerm, O.P. Lines (cont.)				
U86-46/2	C46/2, 86342	18	3.3	3.7
R778(Iso)	RZM-ER R578 (C78)	21	2.7	3.3
R778%	RZM-ER-% R578 (C78)	23	2.7	3.3
R780	RZM-ER R580 (C80NB)	24	2.7	3.7
R780/2	RZM-ER R580-# (C80)	27	3.0	4.0
R780-45	RZM-ER R580-45 (C80-45)	24	3.3	3.3
R781	RZM-ER R581	25	3.0	4.3
R781-43	RZM-ER R581-43	24	3.3	4.0
R776	RZM-ER R576	25	3.3	3.3
R776-89-5	Inc. R576-89-5 (C76-89-5)	23	4.0	4.0
R776-89-5NB	Inc. R576-89-5NB	19	4.0	4.0
97-C37	Inc. U86-37 (C37)	28	2.7	3.0
R779	RZM R679 (C79-1, *Rz*)	23	2.7	3.0
R724	RZM R824 (C79-2, WB41)	24	3.0	3.3
R725	RZM R425 (C79-3, WB42)	25	3.3	3.3
R735	RZM R635 (C79-7, SES)	26	3.3	4.0
R736	RZM R636 (C79-8, R22)	24	2.7	3.3
R746	RZM R646	25	2.3	3.0
R746(Sp)	Inc. R646,R653	22	2.7	3.0
R753	RZM R653	24	2.3	3.0
R753(Sp)	Inc. R653,R646	25	3.0	3.3
R754	C37 x RZM R646,R653	23	3.0	3.0
R740	RZM-ER R540%,R540-1,R551	27	2.7	3.0
R770	RZM-ER R570	25	3.0	3.7
Y765	RZM-ER Y565	24	3.0	4.0
Y766	RZM-ER Y566	25	3.3	3.3
Y767	RZM-ER Y567 (C67)	24	3.3	4.0
Y771	RZM Y671	25	3.3	4.0
Y772	RZM Y672 (C72)	25	3.3	3.7
Y773(Iso)	RZM Y673R	25	3.0	3.3
Y775	Y-Rrr(C) x Y74(C)	18	3.3	4.3
F86-31/6	C31/6, 86263	12	3.7	4.3
Y768	RZM-ER Y568	25	3.3	3.3
Y769(Iso)	RZM-ER Y569 (C69)	24	3.7	3.7
Y769(Sp)	Inc. Y669	21	3.0	3.7
97-C37	Inc. U86-37 (C37)	25	2.7	3.0
R726	RZM-ER R526 (C26)	24	3.0	3.7
R727A	C37 x RZM *Bvm*	24	3.0	3.0
R727B	Y569rr x RZM *Bvm*	22	3.0	3.7
US H11	111102	21	2.3	3.0

CURLY TOP EVALUATION, SALINAS ENTRIES, KIMBERLY, ID., 1998

(cont.)

Variety	Description	Stand Count No.	CT 08/98	CT 09/98
Multigerm, S^f,Aa Populations & Lines				
769H31	6931aa x Y669	22	2.7	3.3
Z731H11	5911-mmaa x Z31(C)	20	3.3	4.0
7926H13	C913-70aa x 926(C)	23	3.7	4.0
R776-89-5H13	C913-70aa x R576-89-5	26	4.0	4.0
R776-89-5H31	6931aa x R576-89-5	25	3.3	3.7
7747	Inc. 5747 (A,aa)	23	2.3	3.3
7931	6931aa x 931(C)	23	2.7	3.3
7926	6931aa x 926(C)	25	3.7	3.7
6924	RZM 5924	23	3.3	4.0
6929	RZM R581H11,…	26	3.7	4.3
6930	RZM R578H11,…	25	3.0	3.7
7920NB	NB-RZM 5920	25	3.7	4.0
7923	RZM-ER 5922,5923	27	4.3	4.3
7924	6924,6929,6930aa x 924(C)	23	4.0	4.0
7927	RZM-ER 5921H18	24	4.0	4.3
P601	PMR P401	26	3.7	3.7
P603	PMR P403 (~CP01)	18	3.0	3.7
P604	PMR P404 (~CP02)	26	3.0	3.3
CR711	RZM R609,R610aa x CR11(C),(CR09,10)	19	3.3	3.7
CR712	6931aa x CR11(C)	21	3.3	3.7
CR713	6260-6263(CTR)aa x CR11(C)	21	2.7	3.7
7932CT	Inc. 6260,…,6263(A,aa)(CTR)	19	3.0	3.3
7201,…	6260…6263aa x CTR	21	2.7	3.0
7202,…CMS	CTR-CMS x 6260…6263	25	2.3	3.0
7933	Inc. 6264-# (RAR)	27	3.3	3.7
7222,…CMS	CMS-RAR x 6931	25	2.7	3.7
Z725	Z625-#(C)aa x Z31(C),(CZ25)	25	3.0	3.7
Z730	Z630-#(C)aa x Z31(C),(CZ30)	21	3.0	3.7
Z731	6931aa x Z31(C)	21	3.3	3.7
6913-70(Sp)	C913-70aa x A (C913-70)	26	4.0	4.7
6918-12	RZM 4918-12	15	4.3	4.3
7911-4-10	RZM 6911-4-10	23	3.7	4.0
7918-21	RZM 6918-21	27	3.3	3.7
7747	Inc. 5747(A,aa)	26	2.3	3.0
R709-1	CR-RZM R509A-1	24	3.3	3.7
R710	CR-RZM R509,R510(C,S_1)	25	3.0	3.0
N724	Inc. N623,N624 (SBCNR)	25	3.0	3.0
N730	Inc. N629,N630 (SBCNR)	24	3.3	3.3

CURLY TOP EVALUATION, SALINAS ENTRIES, KIMBERLY, ID., 1998

(cont.)

Variety	Description	Stand Count	CT	CT
		No.	08/98	09/98
Monogerm, S^f,Aa Populations & Lines				
N766M	Inc. N665,N666, (SBCNR)	26	3.3	3.3
6546	Inc. F82-546 (C546)	23	3.0	3.3
6562	Inc. F82-562 (C562)	24	3.0	3.0
6718	Inc. U83-718 (C718)	23	3.0	3.3
6762-17	Inc. 0762-17 (C762-17)	22	2.7	3.0
6796-43	Inc. 0796-43 (C796-43)	25	3.3	3.7
7835	6833,…aa x 835(C), (CTR,T-O,*Rz*)	24	2.7	3.3
7835H50	C790-15CMS x 835(C)	24	2.7	3.0
7835H87	6890aa x 835(C)	26	2.7	3.3
7834NB	NB-RZM 5834,5893(A,aa)	25	3.0	3.3
7838	6828,…aa x 838(C), (CTR,T-O,VYR,*Rz*)	22	2.7	3.0
7838H50	C790-15CMS x 838(C)	24	2.7	3.3
7864-14M	Inc. 5864-14, C864-14	27	3.0	3.7
7867-1M	Inc. T-O 6867-1(CTR), C867-1	19	2.7	3.0
6911-4-7	RZM 5911-4-7, C911-4-7	19	3.3	3.3
6831-4	RZM-T-O 4831-4mm, C831-4	18	3.7	4.3
7869-6	T-O 6869-6	26	3.7	4.0
7869M	RZM-ER 5869	28	3.0	3.7
7869NB	NB-RZM 5869	25	3.0	3.7
7895M	NB-RZM 5895	24	3.0	4.0
7890	RZM-ER 5890 (C890-1,*Rz*)	26	3.3	3.7
7848	0790aa x 848(C)	24	3.0	3.7
7810NBM	NB-RZM 5810 (C890-#)	25	2.7	3.0
7812M	RZM 6812M (C890-2/3,WB41,42)	29	2.7	3.3
7815M	RZM 6815M (C890-5,R04)	26	2.7	3.0
7817%	RZM-ER 5817 (C890-7,SES)	27	3.0	3.7
7818%M	RZM-ER 5818 (C890-8,R22)	29	3.7	4.0
7819M	RZM 6819M (C890-9,WB151)	23	3.7	4.3
7820M	RZM 6820M (C890-10,WB169)	26	3.3	3.7
7821M	RZM 6821M (C890-11,WB258)	29	3.7	4.0

TEST 2498. ERWINIA/POWDERY MILDEW EVALUATION OF LINES & POPULATIONS, SALINAS, CA., 1998

160 entries x 3 replications, sequential
1-row plots, 17 ft. long

Planted: March 30, 1998
Not harvested for yield

Variety	Description	Powdery Mildew				Harvest Count	Stand Count	Erwinia Rating	
		08/07	08/20	09/11	Mean	Mean	Mean	DI	%R
Block 1									
Multigerm, Open-pollinated									
E740	Inc. E840 (C40),susc. ck.	4.7	7.3	7.0	6.7	33	31	46.4	45.9
97-SP22-O	Inc. SP76-22-0	3.3	5.7	5.7	5.2	35	33	8.4	83.7
268	Inc. 768 (US75)	4.3	6.7	7.0	6.1	30	30	13.1	81.3
97-US75	Inc. 268 (US75)	3.7	6.3	7.0	5.8	30	29	15.3	65.9
97-US22/3	Inc. Y009 (US22/3)	4.0	6.3	7.0	5.8	28	32	14.5	79.6
US H11	L111102, 9-24-96	4.0	6.7	6.3	5.7	30	28	2.4	89.2
U86-37	C37, L86443	4.7	7.0	6.3	6.2	27	25	1.2	96.9
97-C37	Inc. U86-37	4.3	6.3	6.0	5.6	33	31	3.0	93.3
U86-46/2	Inc. C46/2, L86342	2.7	4.3	5.3	4.3	23	24	2.5	92.9
R678(Iso)	NB-RZM R478NB (C78)	3.0	5.0	5.0	4.6	31	31	3.4	94.4
R778(Sp)	Inc. R678(Iso) (C78)	3.0	5.3	5.3	5.0	27	30	5.0	91.6
R778(Iso)	RZM-ER R576(Sp),…(C78)	3.0	5.3	5.3	4.6	31	30	2.0	96.6
R778%	RZM-ER-%S R578,R578/2,R578%	2.7	5.0	5.0	4.4	33	33	1.0	98.1
R639	RZM R539 (C39R)	2.0	4.3	4.7	3.7	31	30	3.3	95.5
R647	RZM-R547 (C47R)	3.3	5.3	4.7	4.8	31	30	0.6	96.8
R770	RZM-ER R570	3.0	6.0	5.3	5.1	29	29	0.9	98.8
Block 2									
R778%	RZM-ER-%S R578,R578/2,R578%	2.3	4.7	5.3	4.3	33	33	6.0	88.5
R639	RZM R539 (C39R)	2.0	4.3	4.7	3.8	31	31	1.2	96.8
R647	RZM-R547 (C47R)	2.0	5.0	5.3	4.4	27	27	0.1	98.7
R770	RZM-ER R570	2.3	5.3	5.3	4.5	26	26	0.1	98.6

TEST 2498. ERWINIA/POWDERY MILDEW EVALUATION OF LINES & POPULATIONS, SALINAS, CA., 1998

(cont.)

Variety	Description	Powdery Mildew				Harvest Count	Stand Count	Erwinia Rating	
		08/07	08/20	09/11	Mean	Mean	Mean	DI	%R
Block 2 (cont.)									
R780/2	RZM-ER R580-# (C80)	3.3	5.3	5.7	4.8	32	31	3.6	93.5
R780(Iso)	RZM-ER R580,R580NB,R580%	2.7	5.3	5.3	4.6	33	32	3.8	94.9
F86-31/6	Inc. C31/6, L86263	3.3	5.7	5.0	4.8	18	15	4.3	79.1
R681	NB-RZMR481-43,-89,…(C82)	3.3	5.0	4.7	4.4	25	25	0.6	97.5
R776	RZM-ER R576	3.0	5.0	5.3	4.7	29	31	10.4	85.2
R781	RZM-ER R581 (C82)	2.3	4.3	4.3	3.8	28	29	1.2	95.6
R781-43	RZM-ER R581-43	3.3	5.7	6.0	5.1	32	33	3.1	94.8
R576-89-18(Sp)	Inc. R476-89-18 (C76-89-18)	2.3	4.3	5.3	4.3	25	25	4.3	90.6
R776-89-5	Inc. R576-89-5 (C76-89-5)	3.3	5.3	4.7	4.7	33	30	0.9	96.7
R776-89-5NB	Inc. R576-89-5NB (C76-89-5)	3.0	5.3	4.3	4.6	30	29	1.4	95.3
E740	Inc. E840 (C40)	6.0	7.3	7.0	7.2	28	27	73.8	18.6
Y768	RZM-ER Y568	3.7	5.0	5.0	4.7	27	29	7.5	90.6
Block 3									
Y669	RZM Y569	2.0	3.7	4.3	3.7	32	31	1.9	96.7
Y769(Sp)	Inc. Y669	2.3	4.3	4.3	4.0	29	27	3.2	92.4
Y769(Iso)	RZM-ER Y569 (C69)	3.0	5.0	5.0	4.6	30	31	0.7	96.8
US H11	L111102, 9-24-96	4.3	6.7	7.0	6.0	28	26	0.4	93.8
R726 (C26)	RZM-ER R526, C37 x *Bvm*-UK	4.7	7.0	6.7	6.3	33	34	4.1	94.1
R727A	U86-37 x Rzm-*Bvm*	4.0	6.0	6.0	5.6	33	29	2.8	95.6
R727B	Y569rr x RZM-*Bvm*	3.0	5.0	4.7	4.3	32	32	1.6	93.5
Y667	RZM Y567	2.7	5.0	5.3	4.3	32	31	0.3	98.8
Y767	RZM-ER Y567 (C67)	2.3	3.3	4.0	3.6	29	30	1.0	99.0
Y765	RZM-ER Y565	4.0	5.7	5.3	5.1	33	32	1.6	94.9
E740	Inc. E840 (C40)	5.3	7.3	7.0	6.8	29	28	69.0	23.2
Y766	RZM-ER Y566	3.0	4.7	4.7	4.3	30	30	1.1	96.9
Y771	RZM Y671	3.7	5.7	4.7	4.9	33	37	3.7	93.5
Y772	RZM Y672 (C72)	3.7	5.3	4.7	4.9	30	30	1.1	96.7
Y773(Iso)	RZM Y673R	4.3	6.7	6.0	5.9	29	28	5.3	88.4
Y766(Sp)	RZM Y666,…	3.7	6.0	5.3	5.3	26	26	5.4	92.3

TEST 2498. ERWINIA/POWDERY MILDEW EVALUATION OF LINES & POPULATIONS, SALINAS, CA., 1998

(cont.)

Variety	Description	Powdery Mildew				Harvest Count	Stand Count	Erwinia Rating	
		08/07	08/20	09/11	Mean	Mean	Mean	DI	%R
Block 4									
Y767(Sp)	RZM Y667,...	2.7	4.0	5.0	4.2	29	30	1.5	96.7
Y771(Sp)	RZM Y671,...	2.7	5.3	5.7	4.9	28	28	5.0	91.4
Y772(Sp)	RZM Y672,...	3.0	5.0	5.7	4.8	27	28	3.1	96.1
Y773(Sp)	RZM Y673,...	3.3	5.7	5.7	5.1	28	27	1.8	95.8
Y775(Sp)	Y-Rrr(C) x Y74(C)	4.0	5.7	5.3	5.0	27	28	2.5	96.3
US H11	L111102, 9-24-96	4.3	6.7	7.0	6.2	29	29	1.3	97.5
97-C37	Inc. U86-37 (C37)	4.7	7.0	7.0	6.2	35	33	1.9	93.9
R779	RZM R679 (C79-1,Rz)	3.7	6.0	5.7	5.3	27	27	0.3	98.7
R736	RZM R636 (C79-8,R22)	5.0	6.3	5.7	5.8	33	35	3.8	94.3
R746	RZM R646 (C79-8,R22)	5.0	7.0	6.3	6.3	30	29	5.8	90.5
R753	RZM R653 (C79-8,R22)	4.0	5.3	5.7	5.3	29	31	0.0	100.0
R740	RZM-ER R540%,R540-1,R551	4.3	6.0	6.7	5.8	32	30	0.4	96.9
R735	RZM R635 (C79-7,SES)	5.0	6.7	6.0	6.1	33	33	4.9	92.0
R724	RZM R824 (C79-2,WB41)	5.0	7.0	6.0	6.1	34	33	5.8	92.1
R725	RZM R425,R525 (C79-3,WB42)	4.7	6.3	6.3	5.9	27	27	13.2	81.0
E740	Inc. E840 (C40)	5.7	7.3	7.3	6.8	22	23	51.1	40.5
Block 5									
E740	Inc. E840 (C40)	5.0	7.3	7.0	6.8	33	45	46.1	39.7
R746(Sp)	RZM R646,R653	4.7	6.3	6.7	6.0	29	28	9.6	79.0
R753(Sp)	Inc. R653,R646	4.0	6.0	6.0	5.5	25	26	2.0	92.1
R754	U86-37 x RZM R646,R653	3.7	6.3	6.7	5.7	27	26	6.2	84.0
P603	PMR P403 (WB97), (~CP01)	2.3	3.7	4.7	3.7	29	31	1.2	96.5
P604	PMR P404 (WB242), (~CP02)	2.7	4.7	5.0	4.4	35	31	0.7	97.3
P601	PMR P401 (WB97/242)	3.7	5.3	5.3	4.9	31	27	0.9	97.6
97-C37	Inc. U86-37 (C37)	3.7	6.7	7.0	5.9	33	28	0.3	98.6

TEST 2498. ERWINIA/POWDERY MILDEW EVALUATION OF LINES & POPULATIONS, SALINAS, CA., 1998

(cont.)

Variety	Description	Powdery Mildew				Harvest Count	Stand Count	Erwinia Rating	
		08/07	08/20	09/11	Mean	Mean	Mean	DI	%R
Multigerm,S^f,Aa Populations									
R609R2	CR-RZM R409R2 (CR09)	3.0	4.7	5.7	4.5	31	31	3.6	91.3
P610R2	CR-RZM R410R2 (CR10)	3.0	5.3	5.3	4.7	28	28	4.0	91.1
R710	CR-RZM R509-#,R510-#(C)	3.0	5.3	5.3	4.8	28	28	1.0	98.9
R709-1	CR-RZM R509A-1 (S_1)	3.7	6.0	5.7	5.3	28	27	3.0	93.6
R709-9	CR-RZM R509A- 9 (S_1)	2.3	4.3	4.7	4.0	29	29	11.5	81.8
R710-10	CR-RZM R510A-10 (S_1)	2.0	4.7	4.7	4.1	8	6	11.1	88.9
R710-14	CR-RZM R510A-14 (S_1)	4.7	6.7	7.0	6.2	21	20	1.6	95.4
CR711	RZMR609,R2;R610,R2aa x CR11(C)	3.0	5.0	5.7	4.6	24	21	0.7	94.2
Block 6									
CR712	6931aa x CR11(C)	2.3	4.3	4.3	3.8	29	27	8.3	88.7
CR713	6260-6263(C)aa x CR11(C)	3.0	5.3	5.3	4.6	26	25	3.9	90.2
CR711H69	6869(Sp)aa x CR11(C)	3.3	5.3	5.3	4.8	29	28	9.5	81.2
7747	Inc. 5747 (A,aa)	4.3	6.0	5.7	5.4	29	25	0.4	94.5
6931	5915aa,…,aa x A(S_1)	2.7	4.7	4.3	4.1	26	26	2.6	93.6
7931	6931aa x 931(C)	3.0	5.0	5.7	4.7	29	25	2.6	90.6
6924	RZM 5924	3.0	5.0	5.3	4.7	25	22	0.9	90.8
7924	6924,6929,6930aa x 924(C)	2.7	4.7	5.7	4.6	27	26	0.1	98.9
7924A	Inc. 6924,6929,6930	2.3	3.7	4.3	3.6	24	24	3.4	92.5
7924(S_1)	6924-#(C)aa x 924(C)	3.0	4.3	4.0	4.0	26	25	0.1	98.7
6929	RZM R581H11,…	3.7	5.0	5.0	4.8	26	23	0.4	97.6
6930	RZM R578H11,…	3.0	5.0	5.0	4.6	28	25	5.6	94.0
7932CT	Inc. 6260-#(C),…,6263-#A(C)	4.0	6.3	5.7	5.4	31	31	5.6	88.2
7933	Inc. 6264-#(C) (Root aphid)	3.0	5.0	5.0	4.6	27	28	6.8	88.4
N724	Inc. N623,N624(g), SBCNR	3.7	6.3	6.3	5.6	28	27	8.7	75.7
N730	Inc. N629,N630(g), SBCNR	3.3	6.0	6.0	5.2	22	21	3.9	90.4

TEST 2498. ERWINIA/POWDERY MILDEW EVALUATION OF LINES & POPULATIONS, SALINAS, CA., 1998

(cont.)

Variety	Description	Powdery Mildew				Harvest Count	Stand Count	Erwinia Rating	
		08/07	08/20	09/11	Mean	Mean	Mean	DI	%R
Block 7									
N766M	Inc. N665,N666(g)	3.0	4.7	5.3	4.6	28	25	0.6	90.8
P602NR	NR P202 (WB97,242)	3.0	5.3	5.7	4.8	34	31	0.4	96.8
E740	Inc. E840 (C40)	5.0	7.7	7.0	6.8	24	24	59.0	34.3
US H11	L111102, 9-24-96	4.3	6.3	6.7	5.8	25	22	0.5	96.7
Z725	Z625-#(C)aa x Z31(C) (CZ25)	3.0	5.0	4.3	4.4	26	28	4.0	90.6
Z730	Z630-#(C)aa x Z31(C) (CZ25)	3.7	5.7	5.7	5.2	27	26	8.0	83.9
Z731	6931aa x Z31(C)	3.3	5.0	4.7	4.5	27	26	5.2	89.7
Z731H11m	5911-4maa x Z31(C)	3.0	5.3	5.3	4.4	24	23	2.1	94.1
Z731H11M	5911-4aa x Z31(C)	2.7	4.0	4.7	4.1	26	27	2.2	95.0
7920NB	NB-RZM 5920	3.7	5.0	5.3	4.7	30	29	13.8	81.8
6921(Sp)	RZM-%S R21(C)	4.0	6.0	5.7	5.3	29	32	2.1	94.5
6926	RZM 5287,P	2.7	4.7	5.0	4.4	30	28	3.0	90.4
6927	RZM 5921H18	3.3	5.7	5.3	4.8	29	30	3.7	87.9
7927(Sp)	6926,6927-#(C)aa x 926(C)	4.0	5.3	5.3	4.9	32	31	6.4	91.2
7927	RZM-ER 5921H18	3.0	5.7	5.0	4.9	27	26	2.4	90.3
7923	RZM-ER 5922,5923	3.7	6.3	6.0	5.5	27	26	0.1	98.3
Block 8									
7926(Sp)	6931aa x 926(C)	2.0	3.7	4.0	3.6	25	25	3.9	93.8
7926H13	6913-70aa x 926(C)	2.7	5.0	6.0	4.9	27	26	1.4	94.8
7926H69	6869aa x 926(C)	3.0	5.0	5.3	4.8	27	27	8.7	82.5
Y769H31	6931aa x Y669	2.3	3.7	4.0	3.6	23	23	2.7	92.9
Y769H69	6869aa x Y669	2.7	4.7	4.3	4.1	29	28	16.5	70.6
R776-89-5H11	5911-4maa x R576-89-5	3.3	5.0	5.7	4.7	25	25	0.9	95.6
R776-89-5H13	6913-70aa x R576-89-5	3.7	5.3	5.7	5.1	29	28	0.4	97.6
R776-89-5H31	6931aa x R576-89-5	3.3	5.7	5.0	4.6	26	25	0.7	94.7

TEST 2498. ERWINIA/POWDERY MILDEW EVALUATION OF LINES & POPULATIONS, SALINAS, CA., 1998

(cont.)

Variety	Description	Powdery Mildew				Harvest Count	Stand Count	Erwinia Rating	
		08/07	08/20	09/11	Mean	Mean	Mean	DI	%R
Block 8 (cont.)									
R776-89-5H69	6869aa x R576-89-5	3.0	4.3	5.0	4.1	28	27	8.6	85.6
6913-70(Iso)	RZM 5913-70 (C913-70)	3.3	5.3	5.7	4.9	29	27	0.0	100.0
6913-70(Sp)	RZM 5913-70aa x A (C913-70)	3.7	6.0	6.3	5.4	28	29	0.4	96.6
7911-4-10	RZM 6911-4-10	3.0	5.3	5.7	4.8	26	26	3.1	87.9
E740	Inc. E840 (C40)	5.0	7.7	7.3	6.9	27	27	71.4	20.7
6918-12	RZM 4918-12	1.0	3.0	3.0	2.7	28	28	0.0	100.0
7918-21	RZM 6918-21	2.0	4.0	4.3	3.8	31	30	5.3	85.4
5911-4(Iso)	NB-ER-RZM 3911-4 (C911-4)	3.0	4.7	5.0	4.2	27	26	2.0	92.5
Block 9									
mm,S^{f},Aa populations and lines									
7835m	6833,...aa x 835(C)	3.3	5.3	5.7	4.8	31	30	10.7	81.1
7835H69	6869aa x 835(C)	3.3	5.3	6.0	5.0	31	31	10.3	72.4
7835H87	6890aa x 835(C)	2.7	5.3	5.7	4.8	29	29	5.0	87.3
7838m	6828,...aa x 838(C)	2.3	5.3	5.7	4.4	31	26	4.7	91.4
7838H10	5911-4H50 x 838(C)	3.0	4.7	5.0	4.6	28	28	8.6	85.7
7848	0790aa x 848(C)	3.3	5.7	5.7	4.9	30	26	6.0	89.6
7848H87	6890aa x 848(C)	4.0	6.0	6.3	5.6	29	29	3.7	85.9
7890	RZM-ER 5890, (C890-1Rz)	3.3	6.0	6.0	5.1	30	29	0.0	100.0
7810NBm	NB-RZM 5810	3.0	4.7	5.3	4.5	31	31	6.8	89.3
7812M	RZM 6812M,m, (C890-2, WB41/42)	4.0	5.7	5.7	5.3	30	30	8.4	86.7
7815M	RZM 6815M,m, (C890-5)	3.7	5.3	5.3	4.8	32	35	7.4	91.3
7816M	RZM 6816M,m, (C890-6)	3.0	5.7	6.0	5.0	32	28	10.7	82.4
7817/2M	RZM 6817M,m, (C890-7)	4.0	6.3	6.3	5.7	33	32	20.7	68.5
7817TO	T-O 6817-#(C)	3.3	5.3	5.3	4.9	22	20	6.7	87.8
7817%M	RZM-ER 5817	5.0	7.0	7.0	6.4	27	25	0.3	95.1
7818-2m	RZM 6818M,m	4.0	6.3	6.0	5.4	30	29	7.4	84.0

TEST 2498. ERWINIA/POWDERY MILDEW EVALUATION OF LINES & POPULATIONS, SALINAS, CA., 1998

(cont.)

Variety	Description	Powdery Mildew				Harvest Count	Stand Count	Erwinia Rating	
		08/07	08/20	09/11	Mean	Mean	Mean	DI	%R
Block 10									
7818TO	T-O 6818B-#(C)	3.7	6.0	5.7	5.3	28	27	16.9	70.0
7818%M	RZM-ER 5818, (C890-8)	3.3	5.3	5.3	5.0	29	25	8.4	84.3
7819M	RZM 6819M,m, (C890-9)	3.3	5.3	5.7	5.0	23	24	9.2	77.0
7820M	RZM 6820M,m, (C890-10)	4.3	6.3	5.7	5.8	27	26	9.0	79.2
7821M	RZM 6821M,m, (C890-11)	4.0	6.0	5.7	5.3	27	27	11.0	79.8
US H11	L111102, 9-24-96	4.7	6.7	6.7	6.0	29	22	3.3	89.4
C40		5.3	8.0	7.0	6.9	27	24	61.3	36.1
7869-6	T-O 6869-6	3.3	5.0	5.7	4.6	30	28	0.0	100.0
7867-1m	T-O 6867-1, C867-1	3.7	5.3	5.7	4.7	31	31	13.3	79.1
7864-14M	Inc. 5864-14, C864-14	4.3	6.1	6.0	5.8	2	2	2.9	88.9
6831-4	RZM,T-O 4831-4mm, C831-4	3.3	6.0	6.0	5.2	21	18	19.9	65.9
6869(Sp)	5869mmaa x A	3.0	4.7	5.7	4.7	30	30	7.1	83.6
7869M	RZM-ER 5869	3.7	5.0	4.7	4.6	33	31	6.3	88.4
7869NBm	NB-RZM 5869	3.3	5.3	5.0	4.7	36	33	3.0	90.6
7834NBm	NB-RZM 5834,5893	4.3	6.7	5.7	5.7	31	31	6.0	84.0
7895M	NB-RZM 5895	4.0	6.0	6.0	5.5	30	29	1.0	95.3
Mean		3.4	5.5	5.6	5.0	28.5	27.9	7.2	87.9
LSD (.05)		1.1	1.0	1.0	0.6	5.8	5.7	8.3	12.5
C.V. (%)		19.1	11.0	11.7	7.7	12.8	12.6	71.8	8.9
F value		5.0**	7.1**	4.6**	13.0**	3.8**	5.0**	19.0**	10.7**

TEST 2598. ERWINIA/POWDERY MILDEW EVALUATION OF EXPERIMENTAL HYBRIDS, SALINAS, CA., 1998

100 entries x 3 replications, sequential
1-row plots, 17 ft. long

Planted: March 30, 1998
Not harvested for yield

Variety	Description	Powdery Mildew				Harvest Count	Stand Count	Erwinia Rating	
		08/07	08/20	09/11	Mean	Mean	Mean	DI	%R
Block 1									
US H11	L113102, 3-18-97	5.0	6.7	6.3	6.1	25	24	0.3	98.8
E740	Inc. E840 (C40)	6.0	8.0	7.3	7.2	28	31	62.2	28.7
E840H72	U83-718HO x C40	4.0	6.0	7.0	5.9	17	19	41.9	48.9
E840H8	F82-546H3 x C40	4.0	6.3	6.7	5.8	22	20	22.6	67.7
Rizor	Spreckels, 9-3-97	4.0	6.3	6.3	5.7	25	29	4.1	91.0
Rival	Holly HH103,L1032406,3-18-97	3.7	6.0	6.3	5.4	31	25	7.3	87.3
SS-NB7R	Spreckels, 173404, 3-3-98	4.0	5.7	5.3	5.2	24	21	8.0	90.5
B4776R	Betaseed, 4776.7033, 9-1-97	3.3	4.7	4.3	4.3	33	32	11.1	84.7
B4035R	Betaseed, 7-10-97	4.0	5.7	5.0	4.9	20	16	16.4	75.5
5KJ0142	Betaseed, PMR-Rz, 8-18-97	2.7	4.7	5.0	4.3	18	18	9.5	84.2
Block 2									
HM7072	Hilleshog, 3.20-4.00, 2-24-98	3.0	4.7	5.3	4.7	20	19	5.2	88.6
B4038R	Betaseed, L6KJ0190, 2-11-98	3.7	5.0	4.7	4.4	37	34	9.6	85.9
SS-NB5R	Spreck,522401,3-3-98(SS-IV2R)	3.7	5.3	6.0	5.2	18	20	5.7	87.2
R778H50	F92-790-15CMS x R678	2.7	5.0	5.3	4.8	29	27	10.8	78.5
Y769H50	F92-790-15CMS x Y669	2.7	5.0	5.3	4.6	32	30	9.6	80.8
R776-89-5H50	F92-790-15CMS x R576-89-5	3.0	4.7	5.3	4.7	31	31	6.6	88.2
R746H50	F92-790-15CMS x RZM 646,R653	4.0	5.7	5.7	5.3	35	33	4.0	92.2
Y774H50	F92-790-15CMS x Y74(C)	3.3	4.7	5.0	4.5	31	31	6.1	86.4
7931H50	F92-790-15CMS x 931(C)	3.3	4.7	4.3	4.3	30	30	4.5	92.1
7924H50	F92-790-15CMS x 924(C)	4.0	5.7	5.7	5.1	30	31	4.6	94.2

TEST 2598. ERWINIA/POWDERY MILDEW EVALUATION OF EXPERIMENTAL HYBRIDS, SALINAS, CA., 1998

(cont.)

Variety	Description	Powdery Mildew				Harvest Count	Stand Count	Erwinia Rating	
		08/07	08/20	09/11	Mean	Mean	Mean	DI	%R
Block 3									
CR711H50	F92-790-15CMS x CR11(C)	3.7	5.7	5.7	5.2	29	30	6.8	87.4
US H11	L113102, 3-18-97	4.7	6.0	6.7	6.0	27	28	1.5	92.6
E740	Inc. E840	5.7	7.3	7.3	7.0	23	24	58.0	31.8
R710H50	F92-790-15CMS x CR-RZM R509-#, R510-#(C)	4.0	5.3	5.3	4.9	28	27	8.5	83.4
R709-1H50	F92-790-15CMS x CR-RZM R509A-1	3.3	5.3	5.3	4.8	28	28	7.2	83.9
R709-9H50	F92-790-15CMS x CR-RZM R509A-9	1.3	3.7	4.0	3.2	29	32	21.5	62.5
R710-10H50	F92-790-15CMS x CR-RZM R510A-10	3.3	4.3	4.7	4.3	28	29	1.1	96.6
R710-14H50	F92-790-15CMS x CR-RZM R510A-14	3.7	5.3	6.0	5.3	33	31	1.5	92.5
6913-70H50	F92-790-15CMS x 5913-70	3.0	4.7	5.0	4.4	32	30	1.1	97.0
7911-4-10H50	F92-790-15CMS x RZM 6911-4-10	3.3	6.0	5.7	5.1	31	27	9.1	81.3
Block 4									
7918-21H50	F92-790-15CMS x RZM 6918-21	2.0	3.7	4.7	3.7	35	35	7.1	87.2
6918-12H50	F92-790-15CMS x RZM 4918-12	2.3	3.0	3.7	3.2	33	33	0.0	100.0
7932CTH50	F92-790-15CMS x 6260-#(C)...	4.0	5.3	5.0	5.1	23	23	7.5	81.7
7933H50	F92-790-15CMS x 6264-#(C)	3.7	5.0	5.0	4.7	24	27	1.6	95.0
R735H50	F92-790-15CMS x RZM R635	4.3	6.7	6.0	5.8	31	32	6.1	87.2
US H11	L113102, 3-18-97	5.0	6.0	6.7	5.8	27	26	2.9	91.4
R779H50	F92-790-15CMS x RZM R679	4.0	5.7	5.3	5.2	34	34	4.8	92.2
R736H50	F92-790-15CMS x RZM R636	4.3	6.0	6.0	5.8	32	32	8.7	83.4
R746H50	F92-790-15CMS x RZM R646	5.3	6.7	6.0	5.9	28	28	8.3	88.0
R753H50	F92-790-15CMS x RZM R653	4.0	6.3	6.0	5.7	34	33	0.5	98.1

TEST 2598. ERWINIA/POWDERY MILDEW EVALUATION OF EXPERIMENTAL HYBRIDS, SALINAS, CA., 1998

(cont.)

Variety	Description	Powdery Mildew				Harvest Count	Stand Count	Erwinia Rating	
		08/07	08/20	09/11	Mean	Mean	Mean	DI	%R
Block 5									
Y771H50	F92-790-15CMS x RZM Y671	3.3	5.3	5.3	4.8	33	32	7.1	84.9
Y772H50	F92-790-15CMS x RZM Y672	2.7	5.0	5.0	4.7	36	32	7.9	88.9
Y773H50	F92-790-15CMS x RZM Y673R	3.3	5.7	5.7	5.2	31	31	1.7	94.2
R778H7	6911-4-7HO x R678	3.0	5.0	5.3	4.4	27	26	6.0	83.7
Y769H7	F92-790-15CMS x Y669	2.3	4.0	5.3	4.0	27	28	4.1	89.0
R776-89-5H7	F92-790-15CMS x R576-89-5	2.7	4.3	4.7	4.1	29	27	2.2	94.5
E740	Inc. E840 (C40)	6.0	7.7	7.0	7.0	28	31	58.3	32.8
R778H37	4807HO (C306CMS) x R678	3.3	4.0	4.3	4.2	30	31	6.4	85.2
Y769H37	F92-790-15CMS x Y669	4.0	4.7	4.3	4.4	31	29	7.3	87.2
R776-89-5H37	F92-790-15CMS x R576-89-5	3.7	5.3	4.7	4.7	29	28	4.1	90.1
Block 6									
R778H69	6869aa x R678	3.3	5.3	5.0	4.8	31	29	4.4	90.2
Y769H69	6869aa x Y669	3.0	5.0	4.7	4.3	31	33	5.6	89.5
Y776-89-5H69	6869aa x R576-89-5	3.3	5.7	4.7	4.9	28	28	2.2	95.3
R746H69	6869aa x RZM R646,R653	5.0	6.7	6.0	5.9	26	24	6.0	87.3
Y774H69	6869aa x Y74(C)	4.0	6.0	6.0	5.3	29	29	6.0	88.4
7931H69	6869aa x 931(C)	3.7	5.3	5.7	5.0	30	29	5.6	87.3
7924H69	6869aa x 924(C)	3.0	5.3	5.3	4.9	29	29	5.3	92.0
CR711H69	6869aa x CR11(C)	4.0	5.3	6.0	5.1	28	29	6.5	88.0
Z731H69	6869aa x Z31(C)	4.0	5.7	6.0	5.4	28	27	5.9	89.3
7926H69	6869aa x 926(C)	4.3	5.7	5.7	5.2	31	30	4.9	88.4

TEST 2598. ERWINIA/POWDERY MILDEW EVALUATION OF EXPERIMENTAL HYBRIDS, SALINAS, CA., 1998

(cont.)

Variety	Description	Powdery Mildew				Harvest Count	Stand Count	Erwinia Rating	
		08/07	08/20	09/11	Mean	Mean	Mean	DI	%R
Block 7									
R776-89-5H27m	6831-4HO x R576-89-5	3.3	5.0	5.3	4.8	30	26	3.7	90.4
R778H31-4M	6831-4aa x R678	3.7	5.7	5.3	5.1	21	25	8.4	82.3
R776-89-5H13	6913-70aa x R576-89-5	4.7	5.7	6.0	5.6	27	28	0.2	97.3
R776-89-5H31	6931aa x R576-89-5	2.7	4.7	4.7	4.3	26	27	0.9	97.5
R776-89-5H11	5911-4maa x R576-89-5	3.3	5.0	5.3	4.7	27	28	2.5	95.2
R776-89-5H11-1	6911-4-1aa x R576-89-5	3.3	5.3	5.7	5.0	24	25	0.4	98.7
R776-89-5H11-15M	6911-4-15aa x R576-89-5	3.3	4.3	5.0	4.4	30	29	0.6	97.8
R778H59M	6859-8HO x R678	4.0	6.0	5.7	5.4	27	27	11.1	80.0
R778H64M	5864-14HO x R678	3.0	5.7	5.7	5.2	23	18	17.4	73.6
R778H93	6891-10HO x R678	4.7	6.0	5.7	5.6	30	29	3.7	91.4
Block 8									
R680H31-3	5831-3aa x RZM R580	3.7	5.7	5.7	4.9	27	27	17.6	74.2
US H11	L113102, 3-18-97	4.0	6.0	6.7	5.5	25	26	1.4	95.0
E740	Inc. E840(C)	5.0	7.7	7.3	6.9	18	20	77.5	17.0
R678H33-5	5833-5aa x R578	3.0	5.0	5.0	4.6	27	26	4.1	93.4
R778H28M	6828aa x R678	3.0	5.7	6.0	5.0	25	23	5.5	85.4
R778H33M	6833aa x R678	3.7	5.7	6.0	5.3	24	24	5.1	87.6
R778H33%M	68H33%aa x R678	3.7	6.0	6.0	5.4	29	29	6.8	87.2
R778H34M	6834%aa x R678	3.7	5.3	5.7	5.2	31	29	7.5	83.6
R778H36	6836aa x R678	3.3	5.3	5.3	5.1	21	20	5.8	89.2
R778H38M	6837aa x R678	4.0	5.7	6.0	5.4	28	28	7.3	87.6
Block 9									
R778H8	F82-546H3 x R678	2.7	5.7	5.7	4.8	26	24	4.0	82.6
R778H18	6818maa x R678	2.7	5.0	5.7	4.8	26	28	4.9	92.1
R778H18-1	6818-1aa x R678	2.7	5.7	5.7	4.7	26	27	3.2	92.9
R778H18-2	6818-2aa x R678	2.3	5.0	5.3	4.7	23	24	1.5	85.7

TEST 2598. ERWINIA/POWDERY MILDEW EVALUATION OF EXPERIMENTAL HYBRIDS, SALINAS, CA., 1998

(cont.)

Variety	Description	Powdery Mildew				Harvest Count	Stand Count	Erwinia Rating	
		08/07	08/20	09/11	Mean	Mean	Mean	DI	%R
Block 9 (cont.)									
R778H18-5	6818-5aa x R678	3.3	5.3	5.3	4.8	23	22	1.8	91.7
R778H18-6	6818-6aa x R678	3.3	5.3	5.7	5.0	29	29	7.8	78.8
R778H18-11	6818-11aa x R678	5.0	7.0	7.0	6.6	25	27	7.1	83.8
R778H18-12	6818-12aa x R678	5.3	7.0	6.7	6.3	24	23	2.0	91.4
R778H18-21	6818-21aa x R678	3.0	5.3	5.7	4.9	16	16	0.5	98.1
R778H18B-1	6818B-1aa x R678	4.0	6.3	6.7	5.8	31	31	1.8	91.4
Block 10									
R778H18B-2	6818B-2aa x R678	3.0	5.7	5.3	4.8	26	25	3.2	83.0
E740	Inc. E840 (C40)	6.0	8.0	7.3	7.2	26	29	47.0	45.8
US H11	L113102, 3-18-97	4.7	6.7	7.0	6.1	23	24	1.7	93.8
R778H17	6817maa x R678	3.7	5.7	6.3	5.4	31	27	13.3	80.3
R778H17-5	6817-5aa x R678	3.3	5.7	5.3	5.2	24	23	5.8	91.6
R778H17-6	6817-6aa x R678	2.3	5.0	5.7	4.6	19	20	7.1	83.1
R776-89-5H39	91-762-17CMS x R576-89-5	3.0	4.7	5.3	4.4	29	26	0.0	100.0
Y769H39	91-762-17CMS x Y669	2.7	4.3	5.0	4.4	18	20	15.8	79.1
Z731H50	F92-790-15CMS x Z31(C)	3.0	4.3	5.0	4.4	26	25	8.3	75.2
Z731H7	6911-4-7HO x Z31(C)	2.3	5.7	5.3	4.7	22	23	5.8	86.1
Mean		3.6	5.5	5.6	5.1	27.4	27.1	9.0	84.8
LSD (.05)		1.1	1.1	1.0	0.7	5.1	5.3	8.1	13.2
C.V. (%)		19.2	13.0	10.5	8.8	11.6	12.1	56.0	9.7
F value		4.8**	4.6**	5.0**	8.4**	5.8**	4.8**	21.0**	9.6**

BETASEED CERCOSPORA LEAF SPOT (CLS) NURSERY, (SALINAS ENTRIES), SHAKOPEE, MN, 1998

Variety	Description	Act[1] Aug 06	%[2] Aug 06	Act[1] Aug 14	%[2] Aug 14	Act[1] Aug 21	%[2] Aug 21	Act[1] Aug 27	%[2] Aug 27	Act[1] Average	%[2] Average
97SP220	Inc. SP7622-0 (Resist. ck)	1.9	78	3.7	93	4.2	87	5.3	88	3.8	88
Y769	RZM-ER Y569 (C69) (Susc. ck)	2.7	109	4.2	106	5.0	104	6.0	101	4.5	104
5KJ0142	Combined *Rz*PMR	3.2	129	4.8	119	6.5	135	9.0	152	5.8	136
R726	RZM-ER R526 (*Bvm* gp) (C26)	2.7	108	4.1	103	5.3	109	6.5	109	4.6	108
R727A	C37 x RZM *Bvm* (*Bvm* gp)	2.7	111	4.1	103	4.8	99	6.0	101	4.4	103
R727B	C69 x RZM *Bvm* (*Bvm* gp)	2.8	113	4.2	105	4.6	96	5.5	93	4.3	100
CR711	RZM R609, R610aa x CR11(C)	2.2	89	3.7	91	4.1	86	5.5	93	3.9	90
CR711H50	C790-15CMS x CR11(C)	2.5	103	4.1	103	5.1	106	6.5	109	4.6	107
CR712	6931aa x CR11(C) (CR09/10)	2.3	92	4.0	100	4.6	96	5.5	93	4.1	96
CR713	6260-6263(CTR)aa x CR11(C)	2.6	103	3.9	97	4.5	94	5.5	93	4.1	96
7932CT	Inc. 6260-6263(CTR) (*Rz*-CTR)	2.1	87	3.6	91	4.4	91	5.8	97	4.0	93
7933	Inc. 6264 (*Rz*-Root Aphid)	2.3	91	4.0	99	4.9	102	6.8	114	4.5	104
R709-1	CR-RZM R509A-1(S_1)	2.1	84	3.5	88	4.5	93	6.0	101	4.0	93
R709-1H50	C790-15CMS x CR-RZM R509A-1	2.8	115	3.8	96	4.7	97	6.5	109	4.5	104
R709-9H50	C790-15CMS x CR-RZM R509A-9	1.9	77	3.6	90	4.3	89	5.0	84	3.7	86
R710	CR-RZM R509,R510 (S_1C)	2.3	92	3.8	95	5.0	104	6.3	105	4.3	101
R710H50	C790-15CMS x CR-RZM R509,R510(S_1C)	2.4	96	4.0	100	4.8	100	5.8	97	4.2	98
R710-10H50	C790-15CMS x CR-RZM R510A-10	2.8	111	4.0	99	5.8	121	6.8	114	4.8	112
R710-14H50	C790-15CMS x CR-RZM R510A-14	2.1	85	3.8	96	4.3	90	5.8	97	4.0	93
Y769H50	C790-15CMS x Y669 (Susc. ck)	2.8	113	4.0	99	5.1	106	6.5	109	4.6	107
Mich. Res. Hybrid Check		2.1	86	3.8	96	3.8	78	4.8	80	3.6	84
Mod. Susc. Hybrid Check		3.0	122	4.4	109	5.9	123	7.5	126	5.2	121
Susc. Canadian Hybrid Check		2.9	117	4.8	120	6.3	131	8.3	139	5.5	129
Resistant Source Check		1.9	75	3.0	75	3.3	68	3.3	55	2.9	66
LSD (.05)		0.44	17.8	0.40	9.9	0.48	9.9	0.79	13.3	0.37	8.5

[1] Actual mean value reading
[2] % of the average of BTS checks

NOTE: Nursery grown and evaluated by Jay Miller and Margaret Rekoske.

FORT COLLINS CERCOSPORA LEAF SPOT (CLS) NURSERY (SALINAS ENTRIES), FORT COLLINS, CO., 1998

Variety	Description	Leaf Spot Evaluation		
		08/25/98	09/03/98	09/08/98
97-SP22-0	Inc. SP7622-0 (LSR ck)	3.17	2.67	3.50
CR711	CR09,CR10aa x CR11(C)	3.17	3.00	3.33
CR711H50	C790-15CMS x CR11(C)	4.17	4.33	5.17
CR712	6931aa x CR11(C)	3.17	2.83	3.33
CR713	6260-6263(CTR)aa x CR11(C)	3.33	2.83	3.50
7932CT	Inc. 6260-6263(A,aa)(CTR)	3.17	2.83	4.00
R790-1	CR-RZM R509A-1 (S_1)	2.83	2.83	3.50
R790-1H50	C790-15CMS x CR-RZM R509A-1	4.17	4.17	4.67
R709-9	CR-RZM R509A-9 (S_1)	2.67	2.83	3.50
R709-9H50	C790-15CMS x CR-RZM R509A-9	3.33	3.50	4.17
R710	CR-RZM R509,R510 (S_1C)	3.00	2.83	3.33
R710H50	C790-15CMS x CR-RZM R509,R510 S_1	3.17	3.00	3.67
R710-10	CR-RZM R510A-10 (S_1)	2.67	3.00	3.67
R710-10H50	C790-15CMS x CR-RZM R510A-10	3.83	4.00	4.67
R710-14H50	C790-15CMS x CR-RZM R510A-14	3.17	3.00	4.00
R726	RZM-ER R526, (C26)	3.33	3.67	4.33
Y769(Iso)	RZM-ER Y569, (C69)	3.67	4.00	4.50
5KJ0142	Combined *Rz*-PMR	5.83	6.83	7.17
7932CT	Inc. 6260-6263(A,aa)(CTR)	3.17	2.83	4.00
Ft. Collins checks				
FC607	97A050	2.50	2.83	3.00
FC709/2	921024	2.83	2.67	3.00
FC708	831085HO	2.83	2.67	3.00
LSR ck	(FC 504CMS x FC 502/2) x SP6322-0	2.67	2.67	3.17
EL 50	East Lansing	2.67	2.83	3.17
EL48	East Lansing	2.67	3.17	3.50
LSS ck	SP351069-0	4.00	4.17	4.50
LSD (.05)		0.70	0.87	0.96

NOTE: Nursery grown and evaluated by Dr. L. Panella.

DAVIS-197. VIRUS YELLOWS (BEET CHLOROSIS VIRUS) EVALUATION OF GERMPLASM & BREEDING LINES, DAVIS, CA., 1997

12 varieties(V) x 2 virus trtmts(T) x 6 reps., Split-plot
1-row plots, 30 ft. long

Planted: May 21, 1997
Harvested:
BChV Inoc.: July 1, 1997

Varieties(V)	Description	Acre Yield Sugar(lbs) Inoc.	Acre Yield Sugar(lbs) Noninoc.	Acre Yield Beets(t) Inoc.	Acre Yield Beets(t) Noninoc.	Sucrose(%) Inoc.	Sucrose(%) Noninoc.	Clean Beets(%) Inoc.	Clean Beets(%) Noninoc.	NO3-N Inoc.	NO3-N Noninoc.
1. R681	NB-RZM R481,R482,R484	3765	4460	11.86	13.76	15.88	16.22	96.4	95.9	38.5	35.6
2. R576-89-18	Inc. R476-89-18	3662	4097	11.56	12.55	15.85	16.33	96.5	96.5	34.5	29.0
3. KW6770	KWS 6770.5193,1-10-97	3611	4385	11.00	12.77	16.43	17.13	95.4	95.7	32.0	31.6
4. Y668	RZM Y568	4158	4570	13.23	14.12	15.78	16.22	95.6	95.4	30.2	24.0
5. Y669	RZM Y569, (~C69)	4544	4727	14.40	14.50	15.80	16.32	96.6	95.8	35.7	32.7
6. Y667	RZM Y567, (~C67)	4298	5060	13.33	15.42	16.20	16.45	95.8	96.3	34.8	28.8
7. Y671	RZM 5205,P;…	4543	4780	14.17	14.61	16.07	16.42	96.2	96.2	28.7	31.3
8. 6925	YR 4909,…,4918-#(S_1)(C)	3703	3713	11.48	11.61	16.12	16.10	95.2	95.7	23.9	31.8
9. 6931	5915,5925aa x A	4041	4339	12.78	13.74	15.83	15.80	95.9	95.6	29.8	33.7
10. 6921H25	5925aa x RZM-%S R21(C)	3849	4378	12.21	13.74	15.77	15.98	95.7	96.2	34.6	27.0
11. P604	PMR P404, (~CP02)	3652	4012	11.39	12.32	16.03	16.30	94.3	94.5	15.7	20.8
12. R678H11M	5911-4Maa x R578(Sp)	4325	4933	13.80	15.38	15.72	16.05	95.6	96.4	28.1	27.0
Virus treatment means		4012.6	4454.4	12.60	13.71	15.96	16.28	95.8	95.8	30.5	29.4
Grand Mean		4233.5		13.16		16.12		95.8		30.0	
C.V. (%) - T x V		11.3		11.90		2.40		0.9		31.8	
LSD (.05) - T		*		NS		*		NS		NS	
LSD (.05) - V		386.1		1.30		0.30		0.7		7.7	
LSD (.05) - T x V		546.0		1.80		0.40		1.0		10.9	
F value - T		8.9*		5.41NS		7.16*		0.1NS		0.1NS	
F value - V		6.5**		6.36**		5.35**		5.1**		2.9**	
F value - T x V		0.8NS		0.55NS		0.88NS		0.9NS		0.8NS	

DAVIS-197. VIRUS YELLOWS (BEET CHLOROSIS VIRUS) EVALUATION OF GERMPLASM & BREEDING LINES, DAVIS, CA., 1997

(cont.)

Varieties (V)	Description	Recover. Sugar (lbs)		Recover. Sugar (%)		Sodium (ppm)		Potassium (ppm)		NH_2-N (ppm)	
		Inoc.	Noninoc.	Inoc.	Noninoc.	Inoc.	Noninoc.	Inoc.	Noninoc.	Inoc.	Noninoc.
1. R681	NB-RZM R481,R482,R484	3352	3964	89.1	89.0	1070	946	915	1011	585	643
2. R576-89-18											
	Inc. R476-89-18	3259	3620	89.0	88.4	923	1008	1195	1356	566	603
3. KW6770	KWS 6770.5193,1-10-97	3242	3959	89.7	90.3	1117	960	1126	1057	482	532
4. Y668	RZM Y568	3697	4053	89.1	88.7	960	992	1235	1587	530	498
5. Y669	RZM Y569	4067	4269	89.5	90.3	1051	760	1137	1169	476	522
6. Y667	RZM Y567	3820	4505	88.9	89.1	991	937	1294	1375	549	557
7. Y671	RZM 5205,P;…	4037	4248	88.9	88.8	1106	942	1212	1328	518	588
8. 6925	YR 4909,…,4918-#(S_1) (C)	3252	3271	87.9	88.1	970	1225	1629	1056	587	608
9. 6931	5915,5925aa x A	3574	3819	88.5	88.1	1122	1037	1273	1477	526	555
10. 6921H25	5925aa x RZM-%S R21 (C)	3423	3860	88.9	88.2	937	1161	1258	1179	551	578
11. P604	PMR P404	3325	3579	91.1	89.1	914	913	1094	1268	381	575
12. R678H11M											
	5911-4Maa x R578 (Sp)	3802	4346	87.9	88.1	1291	1143	1290	1196	523	609
Virus treatment means		3570.8	3957.8	89.0	88.9	1037.6	1001.8	1211.4	1254.9	522.9	572.2
Grand Mean		3764.3		88.9		1019.7		1238.1		547.5	
C.V. (%) - T x V		11.2		1.6		31.6		25.5		13.0	
LSD (.05) - T		*		NS		NS		NS		**	
LSD (.05) - V		342.2		1.1		260.6		255.4		57.5	
LSD (.05) - T x V		484.0		1.6		368.6		361.2		81.3	
F value - T		8.7*		0.9NS		0.5NS		0.3NS		19.2**	
F value - V		6.6**		3.2**		0.9NS		2.0*		4.1**	
F value - T x V		0.8NS		0.8NS		0.8NS		1.6NS		1.8NS	

DAVIS-297. VIRUS YELLOWS (BEET CHLOROSIS VIRUS) EVALUATION OF COMMERCIAL & EXPERIMENTAL HYBRIDS, DAVIS, CA., 1997

12 varieties(V) x 2 virus trtmts(T) x 6 reps., Split-plot
1-row plots, 28 ft. long

Planted: May 21, 1997
Harvested:
BChV Inoc.: July 1, 1997

Varieties(V)	Description	Acre Yield Sugar(lbs) Inoc.	Acre Yield Sugar(lbs) Noninoc.	Acre Yield Beets(t) Inoc.	Acre Yield Beets(t) Noninoc.	Sucrose(%) Inoc.	Sucrose(%) Noninoc.	Clean Beets(%) Inoc.	Clean Beets(%) Noninoc.	NO3-N Inoc.	NO3-N Noninoc.
KW6770	KWS 6770.5193,1-10-97	3970	4836	12.49	14.56	15.90	16.60	95.5	95.3	58.9	60.8
B4454	BTS 4454.6382,2-20-97	4827	5766	15.45	17.80	15.64	16.20	93.8	95.5	56.8	62.4
B4776R	BTS 4776.6102,2-20-97	5293	5754	17.37	18.69	15.27	15.41	95.7	95.8	66.6	66.2
SS-781R	Spreckels L941000,9-4-96	4779	4887	15.96	16.20	15.00	15.09	95.8	96.0	52.0	46.7
Rival	HH103,8-29-95	4147	5467	13.70	18.11	15.11	15.12	95.8	96.2	71.3	85.5
R581H50	C790-15CMS x RZM R481-#s	5496	6053	17.32	19.37	15.90	15.65	96.0	95.2	49.0	53.8
R576-89-18H50	C790-15CMS x R476-89-18	5146	5751	16.89	18.11	15.24	15.90	95.0	96.3	50.3	48.0
6913-70H50	C790-15CMS x 5913-70(C913-70)	5354	6139	17.20	19.19	15.59	16.00	95.0	95.2	42.4	42.2
6931H50	C790-15CMS x 931(C)	4815	5468	15.58	17.45	15.47	15.68	94.7	95.3	46.6	46.4
Y671-H50	C790-15CMS x Y71(C)	4733	5617	15.30	17.85	15.48	15.74	95.2	95.0	42.2	44.3
6921H50	C790-15CMS x RZM-%S R21	4558	5407	14.65	17.03	15.58	15.89	95.3	94.8	45.3	56.8
6869H11M	5911-4Maa x 5869mm	3946	5016	12.89	16.16	15.30	15.50	95.0	96.2	58.1	61.8
Virus treatment means		4755.3	5513.4	15.40	17.54	15.50	15.70	95.2	95.6	53.3	56.2
Grand Mean		5134.4		16.47		15.60		95.4		54.8	
C.V.(%) - T x V		10.8		10.44		3.30		1.0		21.1	
LSD (.05) - T		**		**		NS		NS		NS	
LSD (.05) - V		447.9		1.39		0.40		0.8		9.3	
LSD (.05) - T x V		633.5		1.97		0.6		1.1		13.2	
F value - T		74.0**		83.91**		5.8NS		0.8		1.5NS	
F value - V		8.0**		9.61**		5.4**		2.3*		9.9**	
F value - T x V		0.9		1.10NS		0.9		1.9NS		0.7**	

DAVIS-297. VIRUS YELLOWS (BEET CHLOROSIS VIRUS) EVALUATION OF COMMERCIAL & EXPERIMENTAL HYBRIDS, DAVIS, CA., 1997

(cont.)

Varieties (V)	Description	Recover. Sugar (lbs)		Recover. Sugar (%)		Sodium (ppm)		Potassium (ppm)		NH_2-N (ppm)	
		Inoc.	Noninoc.	Inoc.	Noninoc.	Inoc.	Noninoc.	Inoc.	Noninoc.	Inoc.	Noninoc.
KW6770	KWS 6770.5193,1-10-97	3439	4230	86.7	87.4	1450	1445	1853	1745	468	468
B4454	BTS 4454.6382,2-20-97	4161	5043	86.3	87.4	1456	1388	1784	1801	492	440
B4776R	BTS 4776.6102,2-20-97	4491	5049	84.8	87.7	1624	1442	2005	1550	494	380
SS-781R	Spreckels,L941000,9-4-96	4066	4165	85.1	85.4	1311	1465	1951	1758	569	549
Rival	HH103,8-29-95	3540	4681	85.3	85.8	1768	1443	1680	1801	462	500
R581H50	C790-15CMS x RZM R481-#s	4766	5188	86.8	85.8	1314	1555	1868	1981	499	468
R576-89-18H50	C790-15CMS x R476-89-18	4438	4933	86.3	85.9	1393	1621	1789	1855	484	488
6913-70H50	C790-15CMS x 5913-70(C913-70)	4560	5245	85.1	85.5	1679	1651	1959	1917	495	522
6931H50	C790-15CMS x 931(C)	4131	4746	85.9	86.8	1497	1366	1907	1680	480	502
Y671H50	C790-15CMS x Y71(C)	4047	4879	85.5	86.9	1520	1254	1686	1973	565	466
6921H50	C790-15CMS x RZM-#S R21	3862	4649	84.8	86.1	1709	1337	1954	1958	506	544
6869H11M	5911-4Maa x 5869mm	3367	4293	85.2	85.5	1651	1333	1802	1917	485	578
Virus treatment means		4072.4	4758.5	85.7	86.3	1530.9	1441.8	1853.1	1827.8	499.9	492.1
Grand Mean		4415.5		86.0		1486.4		1840.5		496.0	
C.V.(%) - T x V		11.1		2.0		21.9		17.0		15.6	
LSD (.05) - T		**		NS		NS		NS		NS	
LSD (.05) - V		394.7		558.1		263.6		252.9		62.6	
LSD (.05) - T x V		1.4		1.9		372.8		357.7		88.5	
F value - T		70.7**		3.8NS		0.8		0.1		0.1	
F value - V		7.7**		1.6NS		0.8		0.6		2.2*	
F value - T x V		0.9		1.0		1.3NS		1.2NS		1.8NS	

A125

TEST C197. CHICORY TRIAL, SALINAS, CA., 1997

12 entries x 8 replications, RCB
2-row plots, 21 ft. long, 2.33 ft. wide

Planted: March 4, 1997
Harvested: October 8, 1997

Variety	Description	Acre Yield Beets[1]	Soluble Solids Brix[2]	Soluble Solids SS[3]	Est. inulin	Root Rot[5]	Roots/ 100'	Roots/ Acre	Roots/ ha	Bolting
		Tons	%	Acre[3]	No.[4]	%	No.	No.	No.	%
Eva	VDH, film coated	36.78	22.64	16642	13314	1.8	209	38954	96216	0.0
Madona	VDH, film coated	38.09	23.89	18229	14583	2.8	206	38509	95118	0.0
Inula '93	SES, raw	39.99	22.50	17986	14389	2.7	206	38398	94843	0.2
Hicor '93	SES, raw	38.00	23.09	17551	14041	1.8	201	37564	92784	0.0
Tilda '93	SES, raw	42.27	23.70	20034	16027	1.8	208	38787	95804	0.2
Candi '93	SES, raw	37.66	22.94	17285	13828	3.3	185	34508	85235	0.2
Bergues	Desprez, 9-17-96	36.22	23.35	16928	13543	4.3	201	37564	92784	0.0
Cassel	Desprez, 9-17-96	40.05	22.33	17886	14309	4.6	202	37787	93333	0.1
Orchies	Desprez, 9-17-96	34.17	24.05	16450	13160	4.2	195	36342	89765	0.0
Rubis	Desprez, 9-17-96	38.19	22.40	17101	13681	5.3	224	41843	103353	0.0
FD96/9	Desprez, 9-17-96	34.40	24.39	16778	13423	1.6	217	40454	99922	0.0
Marlene	HH, raw	35.09	24.45	17209	13768	1.6	209	38954	96216	0.0
Mean		37.58	23.31	17506.7	14005.3	3.0	205.1	38305.4	94614.3	0.1
LSD (.05)		2.64	0.82	1469.5	1175.6	2.2	21.1	3943.0	9739.2	0.3
C.V. (%)		7.06	3.52	8.4	8.4	72.8	10.3	10.3	10.3	501.5
F value		6.74**	7.14**	3.4**	3.4**	3.0**	1.8NS	1.8NS	1.8NS	0.7NS

NOTES:
[1] Roots.
[2] Brix measured from brei obtained from Spreckels rasp (same as used for beet).
[3] Soluble solids, lbs per acre (wt x brix).
[4] Est.lbs inulin per acre, where SS per acre x 80% inulin = lbs/a.
[5] Root rot of unknown (undetermined) etiology, somewhat superficial but also causing complete root loss.

Very good test. High rate of N (same used on sugarbeet) of at least 250 units/a. Very minor powdery mildew. No insect or pest problem observed. Bolting minor. Kerb used for weed control.

TEST C297. CHICORY OBSERVATION TRIAL, SALINAS, CA., 1997

24 entries x 6 replications, RCB
1-row plots, 21 ft. long

Planted: March 4, 1997
Harvested: October 8, 1997

Variety	Description	Acre Yield Beets	Soluble Solids Brix	Soluble Solids SS	Est. inulin	Root Rot	Roots/ 100'	Roots/ Acre	Roots/ ha	Bolting
		Tons	%	Acre	No.	%	No.	No.	No.	%
Eva	VDH, 2-27-97	34.62	22.43	15539	12432	4.8	200	37343	92236	0.0
Dageraad	VDH, 2-27-97	35.30	24.12	16993	13594	2.4	201	37491	92602	0.0
Marlene	VDH, 2-27-97	32.46	23.42	15236	12189	1.8	199	37194	91870	0.0
Katrien	VDH, 2-27-97	31.06	24.70	15346	12277	9.4	186	34675	85648	0.0
Halle	VDH, 2-27-97	36.86	24.07	17751	14201	3.6	200	37343	92236	0.0
Hicor	SES, 2-27-97	37.18	23.00	17079	13663	4.5	186	34675	85648	0.0
Inula	SES, 2-27-97	36.22	22.38	16206	12966	5.2	205	38232	94432	0.0
Tilda	SES, 2-27-97	39.40	22.15	17468	13974	2.2	213	39862	98459	0.4
Candi	SES, 2-27-97	38.67	22.87	17694	14155	5.6	202	37787	93334	0.0
SCI9601	SES, 2-27-97	40.27	23.03	18562	14850	2.7	198	36898	91138	0.0
W2S39727	SES, 2-27-97	32.56	22.45	14630	11704	6.2	168	31415	77596	0.0
W4S39332	SES, 2-27-97	39.94	22.65	18137	14509	5.3	189	35268	87112	0.3
W4S39334	SES, 2-27-97	36.31	23.97	17397	13918	5.3	234	43715	107975	0.0
W4S39339	SES, 2-27-97	35.62	23.60	16787	13430	3.5	210	39269	96994	0.0
W4S39340	SES, 2-27-97	39.15	24.07	18889	15111	6.2	220	41047	101387	0.0
W4S39343	SES, 2-27-97	35.54	24.50	17389	13911	2.9	197	36750	90772	0.0
W4S39345	SES, 2-27-97	39.61	23.33	18481	14785	6.2	217	40603	100289	0.0
W4S39351	SES, 2-27-97	35.49	24.83	17634	14107	2.4	199	37194	91870	0.0
W4S39352	SES, 2-27-97	37.24	23.10	17230	13784	9.7	217	40603	100289	0.0
W4S39392	SES, 2-27-97	36.14	23.92	17253	13803	5.6	210	39269	96994	0.0
W4S39393	SES, 2-27-97	34.62	25.72	17806	14245	3.7	200	37343	92236	0.0
W4539394	SES, 2-27-97	30.79	25.45	15673	12539	5.3	203	37935	93700	0.4
W5W2066	SES, 2-27-97	38.99	23.37	18214	14571	3.3	204	38084	94066	0.0
W5S3816	SES, 2-27-97	40.83	23.15	18932	15146	6.1	232	43418	107243	0.3
Mean		36.45	23.59	17180.3	13744.2	4.8	203.8	38058.9	94005.4	0.1
LSD (.05)		3.78	0.92	1927.2	1541.8	5.9	46.6	8706.3	21504.5	0.4
C.V. (%)		9.06	3.42	9.8	9.8	109.1	20.0	20.0	20.0	604.6
F value		4.48**	8.57**	3.0**	3.0**	0.9NS	0.8NS	0.8NS	0.8NS	0.9NS

NOTES: See Test C197.

TEST C397. EVALUATION OF CHICORY AT SALINAS, CA., MAY PLANTING, 1997

16 entries x 8 replications, RCB
2-row plots, 14 ft. long, 2.33 ft. wide

Planted: May 8, 1997
Harvested: November 24, 1997

Variety	Description	Acre Yield Beets Tons	Soluble Solids Brix %	Soluble Solids SS Acre	Est. inulin No.	Roots/ 100' No.	Roots/ Acre No.	Roots/ ha No.	Bolting %
Desprez entries									
Bergues	9-17-96	30.90	23.33	14412	11530	215	40093	99030	0.0
Cassel	9-17-96	32.91	22.79	14985	11988	199	37259	92030	0.2
Orchies	9-17-96	30.12	23.63	14213	11371	200	37426	92442	0.0
Rubis	9-17-96	32.87	22.65	14901	11921	207	38676	95530	0.2
FD96/9	9-17-96	28.51	23.21	13253	10603	218	40760	100677	0.0
From Holly Sugar									
SCI9601	2-27-97	34.85	22.48	15664	12531	209	39093	96559	0.2
Hicor	2-27-97	34.24	23.30	15931	12744	202	37676	93059	0.2
Inula	2-27-97	33.31	22.26	14817	11853	206	38426	94912	0.3
Tilda	2-27-97	33.87	22.61	15320	12256	205	38343	94707	0.2
Candi	2-27-97	32.08	23.46	15067	12053	203	37843	93471	0.9
Eva	2-27-97	30.28	23.10	13998	11198	208	38759	95736	0.0
Dagerraad	2-27-97	29.43	24.90	14633	11706	206	38509	95118	0.0
Marlene	2-27-97	29.11	24.63	14325	11460	203	37843	93471	0.0
Katrien	2-27-97	27.85	24.36	13573	10859	215	40093	99030	0.0
Halle	2-27-97	30.77	23.29	14302	11442	212	39676	98001	0.4
Madona	9-5-96 (film)	35.90	23.14	16610	13288	202	37676	93059	0.0
Mean		31.69	23.32	14750.3	11800.2	206.8	38634.5	95427.1	0.2
LSD (.05)		2.37	1.03	1209.3	967.5	22.6	4223.1	10431.2	0.6
C.V. (%)		7.56	4.47	8.3	8.3	11.0	11.0	11.0	334.8
F value		8.10**	4.20**	4.0**	4.0**	0.5NS	0.5NS	0.5NS	1.4NS

TEST C497. EVALUATION OF CHICORY AT SALINAS, CA., MAY PLANTING, 1997

16 entries x 8 replications, RCB(E)
1-row plots, 14 ft. long, 2.33 ft. wide

Planted: May 9, 1997
Harvested: November 24, 1997

Variety	Description	Acre Yield Beets	Soluble Solids Brix	Soluble Solids SS	Est. inulin	Roots/ 100'	Roots/ Acre	Roots/ ha	Bolting
		Tons	%	Acre	No.	No.	No.	No.	%
Madona	9-5-96 (film)	29.61	23.92	14146	11317	203	38010	93886	0.0
W2S39727	2-27-97	29.52	22.60	13355	10684	212	39678	98004	0.8
W4S39332	2-27-97	34.63	22.91	15854	12683	210	39177	96768	0.5
W4S39334	2-27-97	31.44	24.30	15273	12218	215	40178	99239	0.0
W4S39339	2-27-97	29.73	24.49	14553	11643	209	39011	96356	0.0
W4S39340	2-27-97	32.43	23.27	15127	12102	207	38677	95533	0.0
W4S39343	2-27-97	30.35	23.60	14351	11481	220	41011	101298	0.0
W4S39345	2-27-97	30.50	23.18	14149	11319	205	38344	94709	0.4
W4S39351	2-27-97	29.90	24.76	14842	11874	217	40511	100063	0.0
W4S39352	2-27-97	33.22	22.90	15237	12189	208	38844	95945	0.0
W4S39392	2-27-97	29.17	24.29	14176	11341	204	38177	94298	0.0
W4S39393	2-27-97	29.64	25.51	15115	12092	209	39011	96356	0.0
W4S39394	2-27-97	26.16	25.01	13169	10535	208	38844	95945	0.0
W5S2066	2-27-97	30.89	24.26	14994	11995	207	38677	95533	0.0
W5S3816	2-27-97	32.96	23.16	15263	12210	207	38677	95533	0.0
W5S10376	2-27-97	30.24	22.92	13867	11094	220	41011	101298	0.0
Mean		30.65	23.82	14591.9	11673.5	210.1	39240.0	96922.7	0.1
LSD (.05)		1.95	1.02	1158.6	926.9	24.1	4492.8	11097.3	0.6
C.V. (%)		6.42	4.31	8.0	8.0	11.6	11.6	11.6	565.1
F value		8.13**	5.79**	3.3**	3.3**	0.4NS	0.4NS	0.4NS	1.3NS

TEST C198. CHICORY TRIAL(Block 4 - North), SALINAS, CA., 1998

8 entries x 6 replications, RCB
2-row plots, 21 ft. long, 2.33 ft. wide

Planted: March 18, 1998
Harvested: October 14, 1998

Variety	Description	Acre Yield Beets[1] Tons	Soluble Solids Brix[2] %	Soluble Solids SS[3] Acre[3]	Est. inulin No.[4]	Root Rot[5] %	Roots/ 100' No.	Roots/ Acre No.	Roots/ ha No.	Bolting %
Madona	VDH,film coated,9-5-96	33.08	24.61	16274	13019	0.0	154	28822	71190	0.0
Orchies	F.Desprez, 2-2-98	29.61	24.39	14453	11563	1.1	152	28451	70274	0.0
Cassel	F.Desprez, 2-2-98	32.12	23.52	15104	12083	0.8	152	28303	69908	0.3
Bergues	hybrid,F.Desprez,2-2-98	29.11	23.63	13755	11004	2.4	152	28303	69908	0.3
Rubis	hyb., F.Desprez, 2-2-98	32.44	23.72	15424	12340	2.5	156	29118	71922	0.0
FD 9807	hyb., F.Desprez, 2-2-98	30.81	23.42	14436	11549	0.3	154	28673	70823	0.0
Faste	Nestle, 3-13-98	25.75	26.40	13616	10893	0.8	159	29785	73569	0.0
Oesie	Nestle, 3-13-98	24.88	24.84	12366	9893	1.9	147	27488	67895	0.0
Mean		29.73	24.32	14428.5	11542.8	1.2	153.2	28617.9	70686.2	0.1
LSD (.05)		2.36	0.76	1299.1	1039.3	2.2	9.6	1784.6	4408.0	0.4
C.V. (%)		6.77	2.67	7.7	7.7	150.9	5.3	5.3	5.3	497.0
F value		13.78**	14.11**	7.1**	7.1**	1.6NS	1.2NS	1.2NS	1.2NS	0.8NS

NOTES:
[1] Roots.
[2] Brix measured from brei obtained from Spreckels rasp (same as used for beet).
[3] Soluble solids, lbs per acre (wt x brix).
[4] Est.lbs inulin per acre, where SS per acre x 80% inulin = lbs/a.
[5] Root rot of unknown (undetermined) etiology, somewhat superficial but also causing complete root loss.

Very good test. High rate of N (same used on sugarbeet) of at least 250 units/a. Very minor powdery mildew. No insect or pest problem observed. Bolting minor. Kerb used for weed control.

TEST C298. CHICORY TRIAL (Block 3 - North), SALINAS, CA., 1998

8 entries x 6 replications, RCB
2-row plots, 22 ft. long, 2.33 ft. wide

Planted: April 29, 1998
Harvested: November 12, 1998

Variety	Description	Acre Yield Beets[1] Tons	Soluble Solids Brix[2] %	Soluble Solids SS[3] Acre[3]	Est. inulin No.[4]	Roots/ 100' No.	Roots/ Acre No.	Roots/ ha No.	Bolting %
Madona	VDH,film coated,9-5-96	36.04	23.00	16563	13250	195	36494	90138	0.0
Orchies	F.Desprez, 2-2-98	31.41	23.98	15067	12053	204	38050	93982	0.0
Cassel	F.Desprez, 2-2-98	35.72	23.09	16513	13211	202	37696	93108	0.4
Bergues	hybrid,F.Desprez,2-2-98	33.73	22.92	15473	12379	203	37908	93632	0.0
Rubis	hyb., F.Desprez, 2-2-98	36.04	22.25	16025	12820	201	37484	92584	0.0
FD 9808	hyb., F.Desprez, 2-2-98	32.88	23.00	15116	12093	199	37272	92060	0.0
Faste	Nestle, 3-13-98	28.98	25.83	14961	11969	191	35786	88392	0.0
Oesie	Nestle, 3-13-98	30.92	24.50	15152	12121	193	36140	89264	0.0
Mean		33.21	23.57	15608.8	12487.0	198.5	37103.2	91645.0	0.1
LSD (.05)		2.37	0.67	1151.9	921.5	21.6	4044.6	9990.2	0.4
C.V. (%)		6.10	2.42	6.3	6.3	9.3	9.3	9.3	692.8
F value		10.24**	24.23**	2.7*	2.7*	0.4NS	0.4NS	0.4NS	1.0NS

Moderate level of spider mites at harvest. Most severe on Faste & Oesie.

NOTES:
[1] Roots.
[2] Brix measured from brei obtained from Spreckels rasp (same as used for beet).
[3] Soluble solids, lbs per acre (wt x brix).
[4] Est.lbs inulin per acre, where SS per acre x 80% inulin = lbs/a.
[5] Root rot of unknown (undetermined) etiology, somewhat superficial but also causing complete root loss.

TEST C197. CHICORY TRIAL, IMPERIAL VALLEY, CA., 1996-97

6 entries x 8 replications, RCB
2-row plots, 21 ft. long

Planted: September 11, 1996
Harvested: June 24, 1997

Variety	Description	Stand Count	Harvest Count	AcreYield Roots	Roots/ 100'	Plants/ Acre	% Bolting	
		No.	No.	Tons	No.	No.	5/16	6/24
Eva	VDH, film coated	81	80	10.53	192	33511	0.0	7.4
Madona	VDH, film coated	84	85	12.15	199	34653	0.1	8.1
Inula '94	SES, raw	83	81	13.70	198	34497	0.8	9.2
Hicor '94	SES, raw	82	83	13.47	194	33874	0.2	10.8
Tilda '94	SES, raw	84	83	10.71	201	34964	0.0	3.0
Candi '94	SES, raw	83	82	11.24	198	34549	0.0	8.9
Mean		82.8	82.2	11.97	196.9	34341.3	0.2	7.9
LSD (.05)		6.7	7.2	1.34	16.0	2788.4	0.6	3.6
C.V. (%)		8.0	8.6	11.06	8.0	8.0	345.5	45.2
F value		0.3NS	0.5NS	8.65**	0.3NS	0.3NS	1.9NS	4.4**

TEST C198. IMPERIAL VALLEY CHICORY TRIAL, IMPERIAL VALLEY, CA., 1997-98

8 entries x 8 replications, RCB
2-row plots, 27 ft. long

Planted: October 6, 1997
Harvested: July 15, 1998

Variety	Description	12 May 1998 Bolters No.	12 May 1998 Bolting %	02 June 1998 Bolters No.	02 June 1998 Bolting %	13 July 1998 Bolters No.	13 July 1998 Bolting %	Roots/ 100'[1] No.	Roots/ acre No.	Roots/ hec No.	Acre Yield t/a
Eva	1997 film coated,VDH	3	2.4	4	3.2	6	5.2	230	60198	148688	12.78
Madona	1996 film coated,VDH	5	3.1	7	4.2	6	3.5	324	84700	209209	16.23
Inula	1997 film coated,SES	5	3.2	6	3.8	8	5.3	278	72661	179471	17.02
Hicor	1997 film coated,SES	7	4.8	9	6.1	9	6.3	273	71330	176184	16.86
Tilda	1997 film coated,SES	12	7.5	13	8.7	13	8.4	282	73689	182012	15.80
Candi	1997 film coated,SES	8	5.0	10	6.2	10	6.0	291	76170	188139	14.98
Orchies	1996 film coated,Desprez	1	0.3	1	0.5	1	0.6	286	74899	185001	14.94
Cassel	1996 film coated,Desprez	2	1.3	3	1.8	4	2.2	318	83309	205772	17.35
Mean		5.4	3.5	6.7	4.3	7.0	4.7	285.2	74619.2	184309.4	15.74
LSD (.05)		4.1	2.3	4.6	2.6	3.4	2.3	41.8	10938.9	27019.1	1.53
C.V. (%)		75.4	65.7	68.5	60.6	47.6	48.5	14.6	14.6	14.6	9.66
F value		6.1**	8.0**	6.5**	8.1**	9.6**	9.7**	3.9**	3.9**	3.9**	7.77**

[1]Test was not thinned (or after thinning), topped seedlings grew again, resulting in a high population and many doubles and multiples.

NOTE: Bolting occurred mainly in row on north side of 40" bed. That is, on 40" double-row beds, essentially no bolting occurred on row on south side (rows ran directly east-west) that had a southern exposure and warmer soil conditions.

Chicory does not appear to be well adapted to winter culture in Imperial Valley. Plants remain small with very low root yield compared to adjacent sugarbeet.

Projects 203 and 281

Specificity of TAS-ELISA for beet necrotic yellow vein virus and its application for differentiating rhizomania resistance in field grown sugar beets.

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The mention of firm names or trade products does not imply endorsement or recommendation by the U.S. Department of Agriculture over other firms or similar products not mentioned.

Abstract

Levels of beet necrotic yellow vein virus (BNYVV) as measured by TAS-ELISA were compared to biological evaluations in representative commercial and experimental sugar beet cultivars ranging in reactions to rhizomania from uniformly susceptible to highly resistant that were developed for production in the United States. Differences in absorbance ($A_{405\ nm}$) values measured among the eight cultivars closely corresponded to allelic dosage and to the frequency of the *Rz* allele that conditions resistance to BNYVV. A diploid (*Rzrz*) hybrid had a significantly lower absorbance value than a similar triploid (*Rzrzrz*) hybrid. Cultivars that segregated (*Rzrz:rzrz*) had higher absorbance values than uniformly resistant (*Rzrz*) hybrids as would be expected. For all cultivars, absorbance values decreased progressively as the season progressed. Absorbance values were significantly positively correlated with rhizomania disease index scores and negatively correlated with individual root weight, plot root weight, and sugar yield. This information is useful in resistance breeding and evaluation programs, and for the sugar industry in consideration of cultivar choice, inoculum production and rotations for future cropping.

Additional keywords: TAS-ELISA, rhizomania, beet soil-borne mosaic virus (BSBMV), *Polymyxa betae*.

Introduction

Rhizomania of sugar beet (*Beta vulgaris* L.) is an economically important disease caused by the beet necrotic yellow vein furovirus (BNYVV). The virus is vectored by the protist-like fungus *Polymyxa betae* (5,16) which survives in infested soil for many years in thick-walled fungal resting structures called cystosori (1,2). Typical symptoms of rhizomania include a constricted taproot referred to as "wineglass" shape, with a proliferation of feeder roots (called "bearding") which appear brown due to the infestation of darkly-colored cystosori and root cell death. In severe infections, taproots show necrosis in the vascular system, or roots can be destroyed which can result in death of the beet (7,21). Even in moderate infestations with rhizomania, sugar content and root yields are depressed. Foliar symptoms associated with an impaired root system appear as chlorotic patches in the field which may correspond to the movement of soil by cultivation equipment. The necrotic yellow vein of the leaf, for which the virus is named, is rarely seen in the field.

Control of rhizomania includes avoidance of infested fields by testing soil for BNYVV prior to planting, fumigation or solarization of soil where permitted, and the use of resistant cultivars (15). A wide range of sugar beet cultivars has been developed with varying degrees of resistance, or tolerance to rhizomania. Previous reports in England (3,4) and the Netherlands (21) showed that sugar beet cultivars with different levels of resistance correlate with the levels of BNYVV detected in roots. Because infected lateral roots remain in the soil after harvest and

viruliferous cystosori survive until the next crop is planted, it is important to plant varieties which do not contribute to increasing levels of BNYVV.

Rhizomania was first recognized in the United States in 1983 in Paso Robles, California (7). Since then, the disease has become widespread throughout California (22,23), and subsequently in other beet growing states (23,24,26). Growers have been reluctant to plant rhizomania resistant seed because of lower yields and lower resistance to other diseases initially associated with these cultivars. However, in newly infested areas, growers have started to use rhizomania resistant cultivars because recently developed cultivars have the yield potential of nonresistant cultivars and are suited to their production conditions.

Resistance to rhizomania in most commercial sugar beet cultivars is conditioned by the dominant allele *Rz* (13) as well as by quantitative factors (12) that appear to modify the expression of *Rz*. A number of cultivars with varying degrees of resistance to rhizomania based on different genetic backgrounds have been developed for the diverse production conditions throughout the United States (13).

One objective of this study was to determine relative levels of BNYVV in representative commercial and experimental sugar beet cultivars developed for production in the United States and to relate the BNYVV levels to allelic dosage of these cultivars. Cultivars selected ranged in their reactions to rhizomania from uniformly susceptible to resistant. Selection of rhizomania resistant parental lines of hybrid cultivars in the U.S. is based on their field performance, which includes symptom evaluation and on analyses for sugar content and root yield. In Europe, selections are commonly made by measuring virus content in ELISA tests from sugar beet seedlings grown under controlled conditions in greenhouses and growth rooms.

An additional objective was to develop an ELISA test that would show a wide range of BNYVV levels in infected roots, and would not cross-react with other furoviruses, thus causing a misdiagnosis of BNYVV (24). Information regarding different levels of BNYVV in resistant cultivars is important for the sugar industry and breeding programs whereby selection of resistant cultivars with the lowest levels of BNYVV available may effect the buildup of rhizomania in soils and give the highest protection.

Materials and Methods

Sugar beet cultivars: Sugar beet varieties were chosen to represent two geographically diverse growing areas in the United States, California and southern Minnesota (Table 1). The identical seed lots of all eight cultivars were grown throughout the study. The cultivar 'USH11' is an obsolete commercial hybrid formerly grown throughout California and is known to be highly susceptible to rhizomania, thus is used routinely in rhizomania studies as the susceptible check. The triploid 'KWS6770' is also susceptible to rhizomania and has been grown extensively in the upper midwestern states. Cultivar 'Beta4776R' is diploid: each plant is believed to carry one dose of the *Rz* allele (*Rzrz*) derived from crossing a *RzRz* parental line with a *rzrz* line, and it is widely grown in California. The 'Beta 4038R' is a triploid hybrid with the same homozygous diploid source of resistance to rhizomania as Beta4776R and likewise carries a single dose of the *Rz* allele but genotypically is *Rzrzrz*. It is targeted to beet growing areas in the upper midwestern United States and the eastern slope of the Rocky Mountains. Cultivar 'HM7072' is being tested for the same areas as 'Beta4038R' and is a diploid hybrid with each plant carrying a single copy of the *Rz* allele. The cultivar 'Rival' has wide adaptation. In addition to carrying the *Rz* allele, it is also reputed to have the rhizomania resistance from the widely grown cultivar 'Rizor'. Cultivar 'SS-781R' is diploid and each plant originally was thought to carry one copy of the *Rz* allele. It

now appears that this hybrid segregates for about 12% susceptible (*rzrz*) plants (Lewellen, unpublished data). The SS-781R has been an important variety in California in rhizomania infested areas, particularly in the San Joaquin Valley. Cultivar '6921H50' is an experimental hybrid developed by the USDA-ARS at Salinas and carries less than 50% frequency of both the *Rz* allele and resistance of unknown inheritance from *Beta vulgaris* spp. *maritima* sources (14).

Serological Analysis of BNYVV: Previous studies have shown that polyclonal antisera to BNYVV cross-react slightly in ELISA tests and in western blot analyses with beet soil-borne mosaic virus (BSBMV), another furovirus infecting sugar beet (22,23). This cross-reactivity is seen whether antiserum is prepared to the purified virions or to the capsid protein (CP) which has been expressed *in vitro* (25) (Fig. 1). The different molecular mass of the BNYVV CP (ca. 22 kDa) compared to that of BSBMV (ca. 24 kDa), however, allows for definitive differentiation of the two viruses in western blot assays (Fig. 1). Monoclonal antibodies produced to BNYVV (courtesy of L. Torrance and G. Grassi) and antiserum prepared to the C-terminal one third of BNVYY CP (courtesy of K. Richards) show complete specificity to all BNYVV isolates tested in both ELISA and western blot assays (23) (Fig. 1, Table 2).

Although western blot analysis provides conclusive distinction between BNYVV and BSBMV, the large numbers of samples to be assayed and the need for quantitation of BNYVV necessitated the use of ELISA tests for these studies. A TAS-ELISA was developed in collaboration with Agdia, Inc. that was specific for BNYVV, with no cross-reactions with BSBMV isolates (Table 2), and had the ability to obtain a wide range of absorbance values for BNYVV. Serial dilutions of BNYVV-infected leaf and root tissues showed a decrease in absorbance readings that corresponded to decreased concentrations of expressed plant sap (data not shown). Previous studies showed a clear relationship between virus concentrations in BNYVV-infected plants and absorbance values obtained in ELISA (17,21). Preliminary TAS-ELISA tests were made to confirm the specificity of this test for BNYVV (Table 2).

Polyclonal antiserum used as the trapping antibody was made from the BNYVV CP which was expressed *in vitro* (kindly provided by K. Richards). The pETH plasmid expressing the CP was identified by western blot assays and was used to transform the appropriate host for expression, *E. coli* strain BL21DE3pLysS, according to Studier et al. (20). An insoluble fusion protein of ca. 22 kDa was overexpressed and purified by SDS-PAGE as previously described (25). Antiserum was prepared in rabbits by Berkeley Antibodies (Richmond, California). This antiserum was used to coat microtiter plates (Immulon I; Chantilly, VA) at a 1/1000 dilution in coating buffer (0.05 M sodium carbonate, pH 9.6).

Plant samples consisted of fibrous lateral roots which had been scraped from each beet, and added to 2 ml of extraction buffer (phosphate-buffered saline, pH 7.2 with 0.5% Tween 20 and 0.4% dry milk powder). Root tissues were macerated in sample extraction bags using a hand held roller press (Agdia, Inc.). Expressed sap was added as paired wells to plates at 150 µl per well. A list of computer-generated random numbers was used to determine the placement of the 576 test samples per harvest on 23 microtiter plates. Each plate also contained paired wells with (i) sample buffer only (ii) a rhizomania diseased root and healthy root tissues in sugar beet (*Beta vulgaris* L.), (iii) a non-inoculated, and (iv) a BNYVV-systemically infected *B. macrocarpa* (*B. vulgaris* spp. *maritima* var. *macrocarpa*) leaf (Table 3).

The BNYVV monoclonal antibody used as the detecting antibody and the goat-anti-mouse IgG-alkaline phosphatase conjugate were provided by Agdia and used according to

instructions. Absorbance readings (A_{405} nm) were made at 15 minute intervals up to 2 hr using a Bio-Tek EL312e microplate reader (Winooski, VT).

Field Trials: Field trials were conducted at the USDA-ARS, U.S. Agricultural Research Station, Salinas, California, where rhizomania tests have been conducted on infested land since 1984. The primary test in this study, Test A, was planted 1 May 1997 in a split-plot design, where harvest dates were the main plot, with eight cultivars (subplots) randomized into three harvest dates (July 14, August 18, October 20), and eight replications. The plots were over-seeded and plants at the two-leaf stage were thinned to a spacing of 16 cm between single plants. Standard best cultural practices were used including weed, insect and disease control. Sprinkler irrigation was used throughout the season at weekly intervals to field capacity in order to enhance rhizomania development. Observations at Salinas over many years has suggested that BNYVV levels, as measured by ELISA, vary depending on timing of irrigation (wetting-drying periods). For this reason, we felt it necessary to measure virus content from the field trial at each harvest three days after the most recent irrigation. For the first two harvests, plots were 2.3 m long with 0.6 m alleys. Excluding end plants, nine beets were randomly harvested within each plot. For the third harvest, plots were longer than for the first two harvests, at 5.2 m long, to accommodate both laboratory and yield evaluations. Plots were adjusted to 3.6 m following consecutive individual plant harvests from 1.6 m near one end of each plot.

In each of the three harvests, the 9 randomly selected beets from each plot (72 plants per cultivar; 576 plants per harvest date) were dug by hand, topped just above the lowest leaf scar, and washed free of soil particles. Fibrous roots were scraped from each beet, 0.5 g of which was taken for the ELISA test. In the first harvest, only the TAS-ELISA was done. In the second and third harvests, TAS-ELISA tests were done, tap roots were individually weighed, and each beet root was scored according to a rhizomania disease index (DI). This root score index was adapted using a scale of 0 to 9 to comply with the international scale for sugar beet germplasm evaluation (Fig. 2) where 0 = no visual symptoms, 1 = very resistant (nearly normal taproot and minor bearding), 3 = resistant (taproot slightly to moderately constricted, moderate bearding and taproot discoloration), 5 = intermediate (taproot wineglass shaped, feeder roots bearded, taproot discolored), 7 = susceptible (severe bearding and stunting, taproot destroyed) and 9 = highly susceptible (death of beet). Beets were harvested mechanically at the end of the third harvest, weighed and run through a standard sugar laboratory to measure sucrose concentration. Sugar yield was calculated from plot weight and sucrose concentration.

In adjacent duplicated field trials, the eight cultivars were evaluated for yield under similar disease pressure and cultural practices. These trials, B, C, D, and E were randomized complete block designs with eight replications. One-row plots were 72 cm wide and 6.1 or 6.4 m long. Test D was hand harvested and topped, and roots were scored for rhizomania on the 0-9 DI scale. Classes 0-3 were considered resistant and 4-9 susceptible. Following root scoring, all beets were bulked by plot, washed, weighed, and run through the sugar analysis laboratory. The other field trials were mechanically harvested for yield and sugar analysis so individual beets were not scored for reactions to rhizomania.

Data analysis: Data from three harvest dates obtained from individual plants (576 plants per harvest) within each plot of test A were averaged and used for statistical analyses. These data consisted of ELISA values, DI (root score), root yield, per cent sucrose, and sugar yield. Initially all data were analyzed for the split-plot analysis at Salinas using MSTAT, where harvest dates were the main plots. Heterogeneity of variances occurred for optical densities as measured by

TAS-ELISA and individual root weights. Analyses of these traits were done with SAS PROC MIXED (SAS Institute Inc., Cary, N.C.). The data were transformed by natural logs which alleviated the heterogeneity for root weights and greatly reduced the heterogeneity for optical densities. For the optical densities and root weights, the means and confidence intervals were transformed back to the original scale. For correlations among absorbance (A_{405nm}), absorbance of test sample/absorbance of healthy roots (abs/H), root score, root weight, per cent sucrose, and sugar yield, the date X variety means were used (Table 4). Data obtained from the individual randomized complete block tests B, C, D, and E to evaluate performance of the eight varieties were also analyzed using MSTAT.

Results

Serological analysis: The TAS-ELISA test modified specifically for this study gave no background cross-reaction with healthy samples or with other furoviruses of sugar beet, in particular, isolates of BSBMV from Texas and Minnesota (Table 2). A wide range of readings were observed with different BNYVV samples of varying serial dilutions, thus providing for the ability to measure differences in BNYVV content among resistant and susceptible sugar beet varieties.

Differences in absorbance (A_{405nm}) values for BNYVV measured by TAS-ELISA among the eight cultivars closely corresponded to dosage and frequency of the *Rz* allele that conditions resistance to BNYVV (Table 3). The diploid *Rzrz* hybrid Beta4776R had a significantly lower value than the similar triploid *Rzrzrz* hybrid Beta4038R. Cultivars that segregated *Rzrz:rzrz* (i.e., SS-781R and 6921H50) had higher absorbance values than the uniformly resistant *Rzrz* hybrids Beta4776R and HM7072.

Field Trials: For all cultivars, differences were observed among harvest dates, with progressively lower absorbance values measured as the season progressed, particularly from July 14 to August 18. A highly significant cultivar with date of harvest interaction occurred. This interaction can largely be explained by rate and magnitude of decrease in absorbance values for the susceptible cultivars compared to the resistant ones. Absorbance readings for the July 14 harvest clearly discriminated differences in varietal reactions more distinctly than did the subsequent harvests (Table 3). Differences in varieties based only upon the TAS-ELISA results from the third harvest date did not show allelic dosage and frequency effects as clearly as in the first two harvests.

There are close associations between the variables used to evaluate reactions to rhizomania, including, absorbance (A_{405nm}), absorbance/healthy, root score and root weight (Table 4). There was nearly a perfect correlation between absorbance readings of test samples and absorbance of test samples divided by those of healthy roots grown in pasteurized soil (absorbance/healthy), indicating extremely low background reactions and very little plate-to-plate variability and experimental error. The highly significant positive correlations between absorbance/healthy values and root scores ($r = 0.87, 0.95$ for dates 2 and 3, respectively) showed that visual disease reaction scores of these roots were highly correlated with virus concentration.

Correlations between absorbance/healthy and root weight ($r=-0.89, -0.76$ for harvest dates 2 and 3, respectively) were negative as would be expected (Table 4). These inverse correlations suggested that high virus concentration or rhizomania disease reactions could be predicted by tap root weight. Root weights and disease scores also were highly inversely correlated ($r = -0.91, -0.87$ at $p = 0.01$ for harvest dates 2 and 3, respectively). Also, as shown by the harvest date results, virus levels decreased through the course of the season.

In addition to the primary test A, in which the roots were evaluated three times during the growing season for reactions to BNYVV by ELISA, the rhizomania disease index, root yield, per cent sucrose, and sugar yield, four additional replicated tests (B, C, D, and E) were grown at Salinas under moderate and severe incidences of rhizomania, as measured by the above parameters (Table 5). Tests B and C were intended to be rhizomania-free, but at harvest it was obvious from root symptoms that these fields were moderately infested. Thus, no rhizomania-free test was available for comparison. In all tests, the two susceptible checks had significantly lower yields than the more resistant entries (Table 5). Comparison of sugar yield between Beta4776R (*Rzrz*) and Beta4038R (*Rzrzrz*) under the two moderate tests (B and C) and the two severe tests (D and E) (Table 5) again suggested that the level of resistance conditioned by allelic dosage was reflected in root yield, per cent sucrose, and sugar yield. Under moderate rhizomania conditions, the yield difference was small (ca. 4%) between these two cultivars and not significantly different, whereas under the severe conditions the difference was larger (ca. 13%) and significantly different. In all tests, under severe disease pressure, the advanced hybrid Beta4776R tended to have the highest root and sugar yields. Roots from test D were individually scored for reaction to rhizomania at harvest. There was a good correlation and comparable ranking of the root score means for varieties across tests D and A for the corresponding harvest date (date 3 for test A). These tests support the data and interpretations made for test A.

Three cultivars for which the genetics are well documented were chosen as the best representatives of distinct allelic dosages to illustrate the association between the *Rz* allele and the three variables which were measured in this study, including absorbance, root score and root weight (Fig. 3). These cultivars range from uniformly susceptible (*rzrzrz*; KWS6770) to diploid resistant (*Rzrz*; Beta4776R) to triploid resistant (*Rzrzrz*; Beta4038R). A strong negative correlation was shown between an increasing dosage of the *Rz* allele and absorbance and root score, but a positive correlation was shown with root weight.

Discussion

Our studies have shown that the current field evaluation system used in the U.S. by industry and public agencies is equally suitable to the more laborious and expensive evaluation by ELISA assays. Using varieties that are currently important to the U.S. beet production, we showed that the ELISA readings are significantly correlated with root score, and negatively with root weight and % sucrose. These readings and evaluations, when compared against a range of rhizomania susceptible and resistant cultivars indicate these data can be useful for prediction of the genetic background of cultivars about which less is known. Root weights and visual scoring are usually made much more easily in a breeding or testing program than absorbance measurements from ELISA tests.

The agronomic data for test A appear to be valid and, under the conditions of these tests, consistently measured and differentiated varietal reactions to BNYVV. There was a high correlation between the dosage and frequency of the *Rz* allele and BNYVV levels in lateral roots, as measured by TAS-ELISA. It would be expected, and it was shown, that within hybrids such as SS-781R, that fully susceptible (*rzrz*) segregants in the hybrid would increase the mean virus content. When individual plant ELISA, visual, and yield ratings were examined and taken into account for hybrids such as SS-781R, the plants that were probably *Rzrz* have values similar to Beta4776R and the putative *rzrz* plants were similar to USH11 or KWS6770. Of more interest was the relationship between allelic dosage and virus levels. It was clear that in terms of virus levels, $Rzrz < Rzrzrz < rzrz \cong rzrzrz$. Incomplete dominance (gene dosage) is a common

phenomenon for host-plant resistance to viruses. Fraser (9) found that many virus resistances inherited at a single locus were expressed in an incompletely dominant manner. Pelsey and Merdinoglu (18) showed that *Rz* was inherited as incompletely dominant when measured by virus content of greenhouse grown plants in standardized inoculum tests. Our results suggest that a further increment of resistance may be achievable in sugar beet hybrids. It is likely that the *RzRz* genotype would then produce less virus than the currently employed *Rzrz* or *Rzrzrz* genotypes. As time and resources permit, it will likely behoove breeders to develop homozygous *RzRz* parental lines for all of the components of commercial hybrid cultivars. These more resistant *RzRz* cultivars could give a higher level of protection against rhizomania and could certainly be important in limiting inoculum buildup in soils. This lag in the use of only *RzRz* parental lines components reflect the time and efforts necessary to incorporate and fix a single gene into all component lines and advanced breeding material. Experimental, homozygous resistant lines are available and will be included in future research along the lines of this study.

Correct diagnosis of BNYVV can be confounded by low levels of cross-reactivity with other furoviruses, in particular BSBMV, as has been previously demonstrated. In addition, levels of BNYVV, which is dependent on the production of viruliferous *P. betae* zoospores, can vary in sugar beets during the growing season in rhizomania-infested fields. This study shows what has been observed over the years by researchers, that levels of BNYVV can change during a growing season. As the season progressed in this study, levels of BNYVV continued to decline as measured by TAS-ELISA, in spite of the presence of well developed rhizomania symptoms, regardless of the cultivar. This could be due to several factors which are unknown at this time but could include plant susceptibility as it declines with age, where younger plants are more susceptible than older ones, or climatic conditions during the season. These results confirm observations over many years at Salinas that late summer BNYVV titer values do not seem to reflect varietal reactions. These results suggest that because of the effects of plant age, environmental factors and/or sampling techniques, timeliness is an important consideration in use of ELISA to evaluate varietal reactions to BNYVV when testing directly from field-grown beets. Because sugar beet is not considered to be a good systemic host for BNYVV due to the extremely low occurrence of systemic symptoms and restriction of BNYVV primarily to the area of proliferated roots (10) the level of BNYVV in sugar beet roots is dependent on the activity of the vector which itself is dependent on soil temperature, soil moisture content, and beet root exudates.

This study shows that the breeder or agronomist can be fairly confident of measuring varietal reactions to rhizomania by scoring and weighing field grown material. Root weights and visual scoring are usually made more easily in a breeding or testing program than absorbance measurements from ELISA tests. This information is useful in resistance breeding and evaluation programs and for the sugar industry in consideration of cultivar choice, inoculum production and rotations for future cropping.

In addition to the *Rz* (Holly source) resistance factor, other sources of resistance to rhizomania have been found (11). Some of these sources appear to be the *Rz* allele, but others appear to be different from *Rz* (19). At least one of the sources, when tested under severe rhizomania conditions provides better protection than *Rz* (11,15). Tests are underway to map each of these sources of resistance, determine their allelism, and identify molecular markers (8,18,19). If additional major genes at different loci are discriminated, these may reduce the vulnerability of *Rz*. In addition, preliminary evidence suggests that one or more of these genes

condition lower levels of BNYVV content than *Rz*. With marker assisted selection, it may become feasible to combine multiple resistance factors into individual cultivars to obtain improved resistance to rhizomania, further decrease BNYVV inoculum production (17), and provide more durable resistance.

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Table 1. Sugar beet hybrids evaluated in virus titer experiments
Salinas, California, 1997 growing season

Identification	Source	Description	Genotype
USH11	USDA-ARS	diploid susceptible	*rzrz*
KWS6770	Betaseed	triploid susceptible	*rzrzrz*
Beta4776R	Betaseed	diploid resistant	*Rzrz*
SS-781R	Spreckels	diploid segregating	*Rzrz:rzrz*
Rival	Holly	diploid resistant	*Rzrz*
HM7072	Novartis	diploid resistant	*Rzrz*
Beta4038R	Betaseed	triploid resistant	*Rzrzrz*
6921H50	USDA-ARS	diploid segregating	*B. maritima* hybid

Table 2. TAS-ELISA readings for BNYVV and BSBMV using BNYVV antisera[a]

Test Sample	Absorbance(A_{405})[b]
BNYVV beet roots	2.227
BNYVV *B. macrocarpa*	2.770
BSBMV-TX *B. macrocarpa*	0.127
BSBMV-MN *B. macrocarpa*	0.132
Healthy beet roots	0.153
Healthy *B. macrocarpa*	0.127

[a] TAS-ELISA using polyclonal (trapping) and monoclonal (detecting) antibodies to BNYVV. Preliminary tests for specificity to BNYVV.

[b] Absorbance at A_{405} represents the average of at least two wells. Tests conducted in greenhouse.

Table 3. TAS-ELISA readings (A_{405}) of BNYVV for varieties, dates of harvest, varieties X dates; test A

Variety	Genotype	July 14	August 18	October 22	Mean
USH11	*rzrz*	0.947[a]a[b]	0.365c	0.226efg	0.513b
KWS6770	*rzrzrz*	1.024a	0.414c	0.341cd	0.593a
Beta4776R	*Rzrz*	0.257def	0.150ghi	0.117hi	0.175de
SS-781R	*Rzrz:rzrz*	0.343cd	0.164fghi	0.140ghi	0.216de
Rival	*Rzrz*	0.316cde	0.138ghi	0.128ghi	0.195de
HM7072	*Rzrz*	0.218efg	0.111i	0.138ghi	0.156e
Beta4038R	*Rzrzrz*	0.562b	0.220efg	0.212fgh	0.332c
6921H50	unknown	0.356cd	0.192fghi	0.155ghi	0.234d
Mean		0.503a	0.219b	0.182b	0.302
Healthy beet root		0.105	0.096	0.102	0.101
BNYVV beet root		0.513	0.372	0.482	0.456
Healthy B.mac.		0.106	0.098	0.103	0.103
BNYVV B. mac.		1.654	1.031	2.345	1.677

[a]Values represent an average of two wells from eight replications of nine beets each.
[b]Within each set of means, those with a letter in common are not significantly different (p=0.05).

Table 4. Coefficients of correlation among treatment means from two harvest dates.[a]

	Absorbance(A_{405nm})	Absorbance/Healthy[b]	Root Score	Root Weight (g)
Absorbance	----------	0.99**	0.87**	-0.89**
Abs/Healthy	0.99**	----------	0.87**	-0.89**
Root Score	0.95**	0.95**	----------	-0.89**
Root Weight	-0.76*	-0.76*	-0.87**	----------

[a] The correlations for harvest date two (August 18) are above the diagonal and those for date three (October 22) are below.
[b]Absorbance at (A_{405nm}) for test samples divided by the absorbance for healthy root samples.
* significant at the 0.05 level of probability.
** significant at the 0.01 level of probability.

Table 5. Performance of sugar beet cultivars under differing severities of rhizomania.

	Test B[a]			Test C[b]		
	Sugar Yield (kg/ha)	Root Yield (t/ha)	Sucrose (%)	Sugar Yield (kg/ha)	Root Yield (t/ha)	Sucrose (%)
Susceptible checks						
USH11	4938	51.6	9.5	5824	56.6	10.3
KWS6770	5406	50.7	10.6	8356	64.0	13.1
Resistant hybrids						
Beta4776R	10848	81.2	13.4	13669	93.7	14.6
SS-781R	8692	72.5	11.9	10948	81.1	13.5
Rival	8789	66.1	13.3	11533	80.9	14.3
HM7072	10294	69.4	14.8	12955	82.1	15.8
Beta4038R	10180	72.5	14.1	13310	84.6	15.7
USDA exp. hybrid						
6921H50	9524	76.9	12.3	11520	84.8	13.6
LSD (P=.05)	946	6.0	0.8	1017	6.1	0.6

[a b] Test B and C grown at Salinas under moderate rhizomania conditions. Planted 10 April 97; Harvested 2 October 1997, 29 September 1997, respectively.

1-row plots, 6.4m long. Eight replications; randomized complete block (RCB) design.

Table 5, cont'd. Performance of sugar beet cultivars under differing severities of rhizomania.

	Test D[c]			Test E[d]				
	Sugar Yield (kg/ha)	Root Yield (t/ha)	Sucrose (%)	Sugar Yield (kg/ha)	Root Yield (t/ha)	Sucrose (%)	Rhizomania Reaction DI[e]	Rhizomania Reaction %R[f]
Susceptible checks								
USH11	5449	47.6	11.0	3528	30.3	11.7	4.6	36.0
KWS6770	6947	53.7	13.0	4735	33.3	14.3	4.5	38.9
Resistant hybrids								
Beta4776R	12333	84.9	14.5	11146	68.0	16.4	2.4	94.9
SS-781R	8838	65.3	13.6	6692	48.1	14.0	3.1	77.1
Rival	8943	63.4	14.2	8413	54.1	15.6	2.8	83.7
HM7072	10820	68.6	15.7	8989	53.5	16.8	3.2	76.9
Beta4038R	10961	68.0	16.2	9454	54.7	17.3	3.5	64.9
USDA exp.hybrid								
6921H50	10478	79.0	13.3	9032	64.8	14.0	2.9	81.7
LSD (P=.05)	1117	7.0	0.8	762	5.0	0.7	0.4	10.3

[cd]Test D and E grown at Salinas under severe rhizomania. Adjacent to Test A. D planted 30 April 97; Harvested 29 October. . E planted 1 May 1997; Harvested 20 October 1997. One-row plots, 6.1m long. Eight replications, RCB.

[e]DI = disease index where individual roots scored at harvest on a scale of 0 (no symptoms) to 9; test E.

[f]%R = % resistant where classes 0-3 were considered resistant; test E.

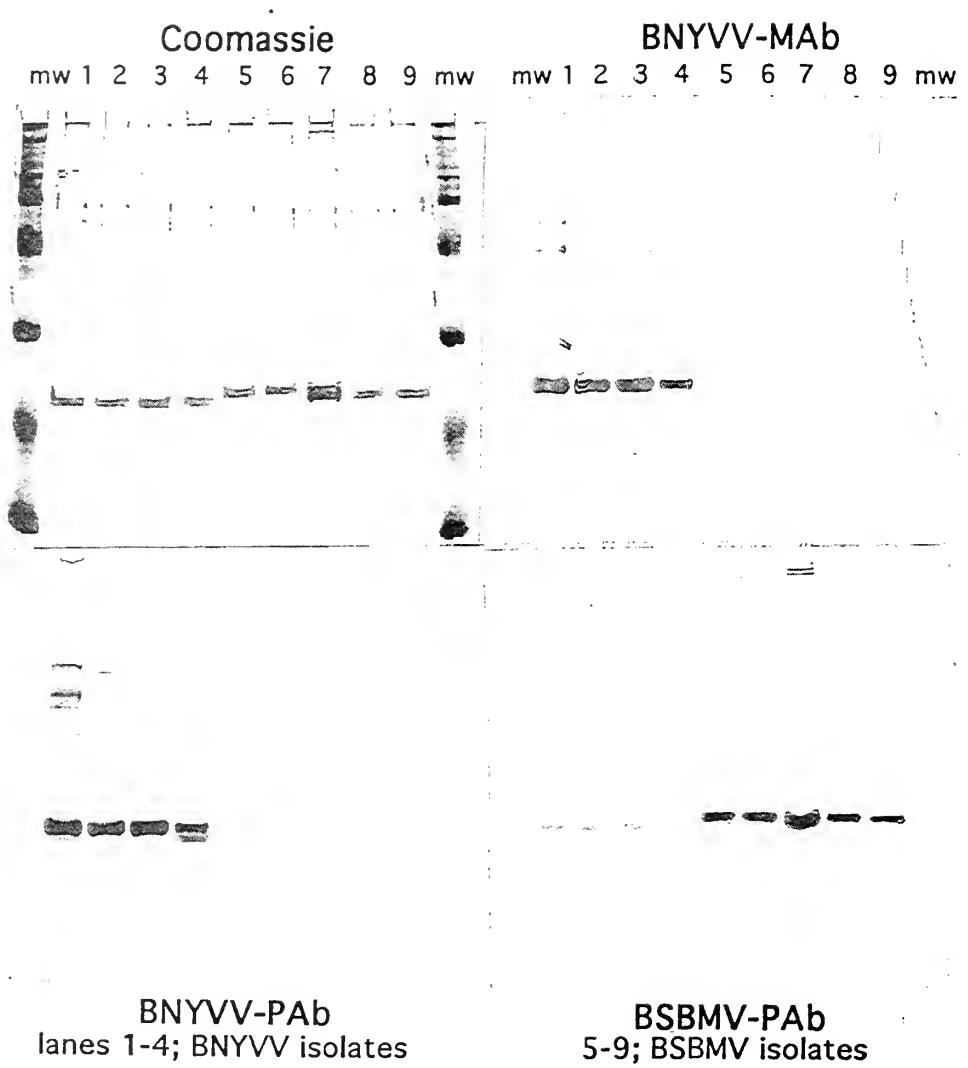

Fig. 1. SDS-PAGE and corresponding western blot of beet necrotic yellow vein virus (BNYVV) and beet soil-borne mosaic virus (BSBMV) isolates:
top left: Coomassie stained gel using purified virus preparations, top right: Western blot using a monoclonal antibody (Mab) to BNYVV, bottom left: Western blot using polyclonal (PAb) BNYVV antiserum, and bottom right: polyclonal antisera to BSBMV.

Lanes 1-4; BNYVV isolates: 5-9; BSBMV isolates.
Lane l; BNYVV-California, lane 2; BNYVV-Nebraska, lane 3; BNYVV-Colorado, lane 4; BNYVV-Minnesota. Lanes 5 and 6; two BSBMV isolates from Texas, lane 7; BSBMV-Nebraska, lane 8; BSBMV-Colorado, lane 9; BSBMV-Minnesota.

The Coomassie gel shows the molecular mass of the BNYVV isolates at ca. 22 kDa and the BSBMV isolates at ca. 24 kDa. The western blots show specificity for BNYVV using the BNYVV MAb, and reciprocal cross-reactivity between BNYVV and BSBMV using respective PAbs.

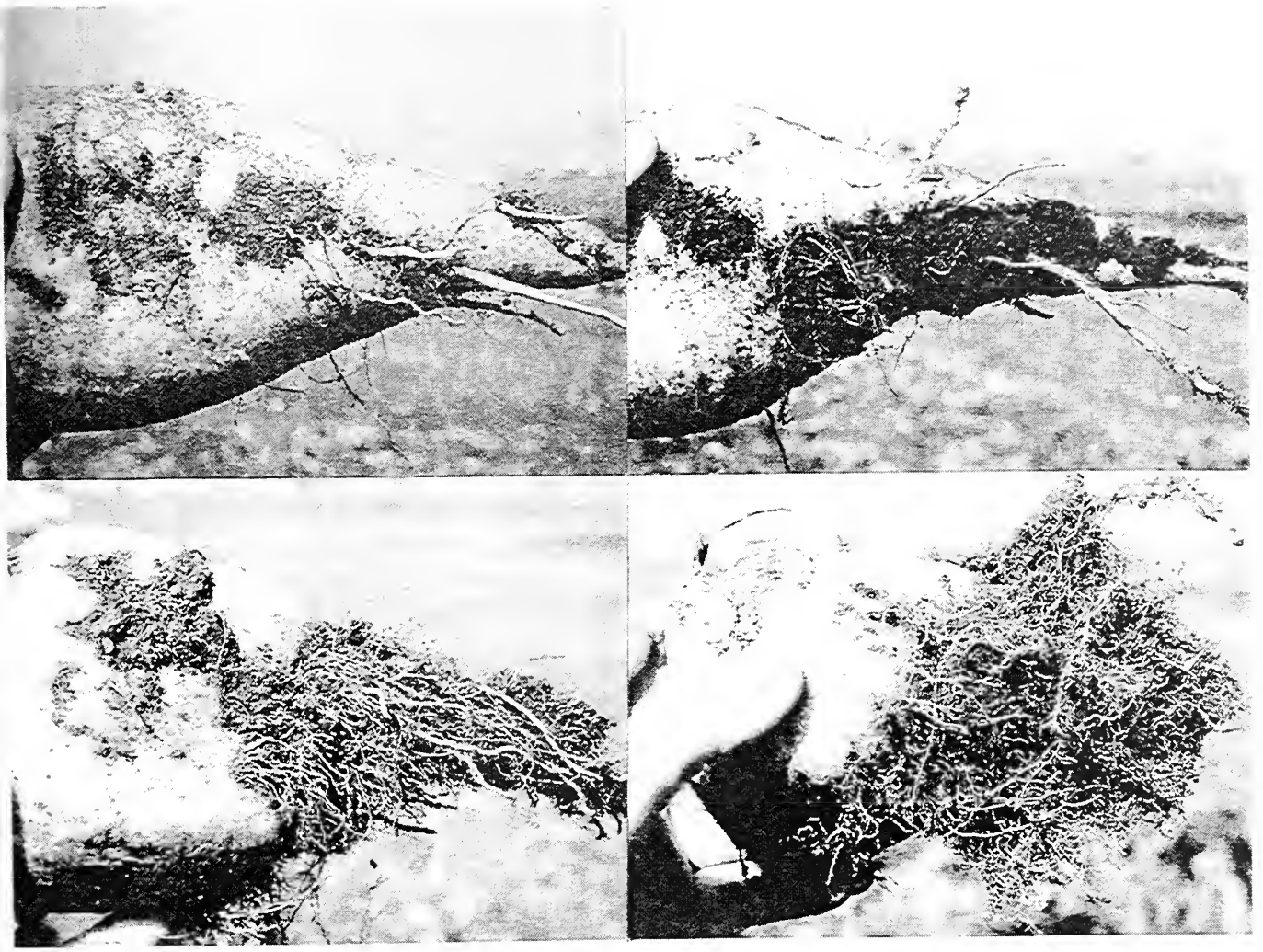

Fig. 2. The rhizomania disease index used in this study was adapted using a scale of 0 to 9 to comply with the international scale for sugar beet germplasm evaluation where 0 = immunity (no visual symptoms; not shown), 1=very resistant (top left; nearly normal taproot and minor bearding), 3=resistant (top right; taproot slightly to moderately constricted, moderate bearding and taproot discoloration), 5=intermediate (bottom left; taproot wineglass shaped, feeder roots bearded, taproot discolored), 7=susceptible (bottom right; severe bearding and stunting, taproot destroyed) and 9=highly susceptible (death of beet; not shown).

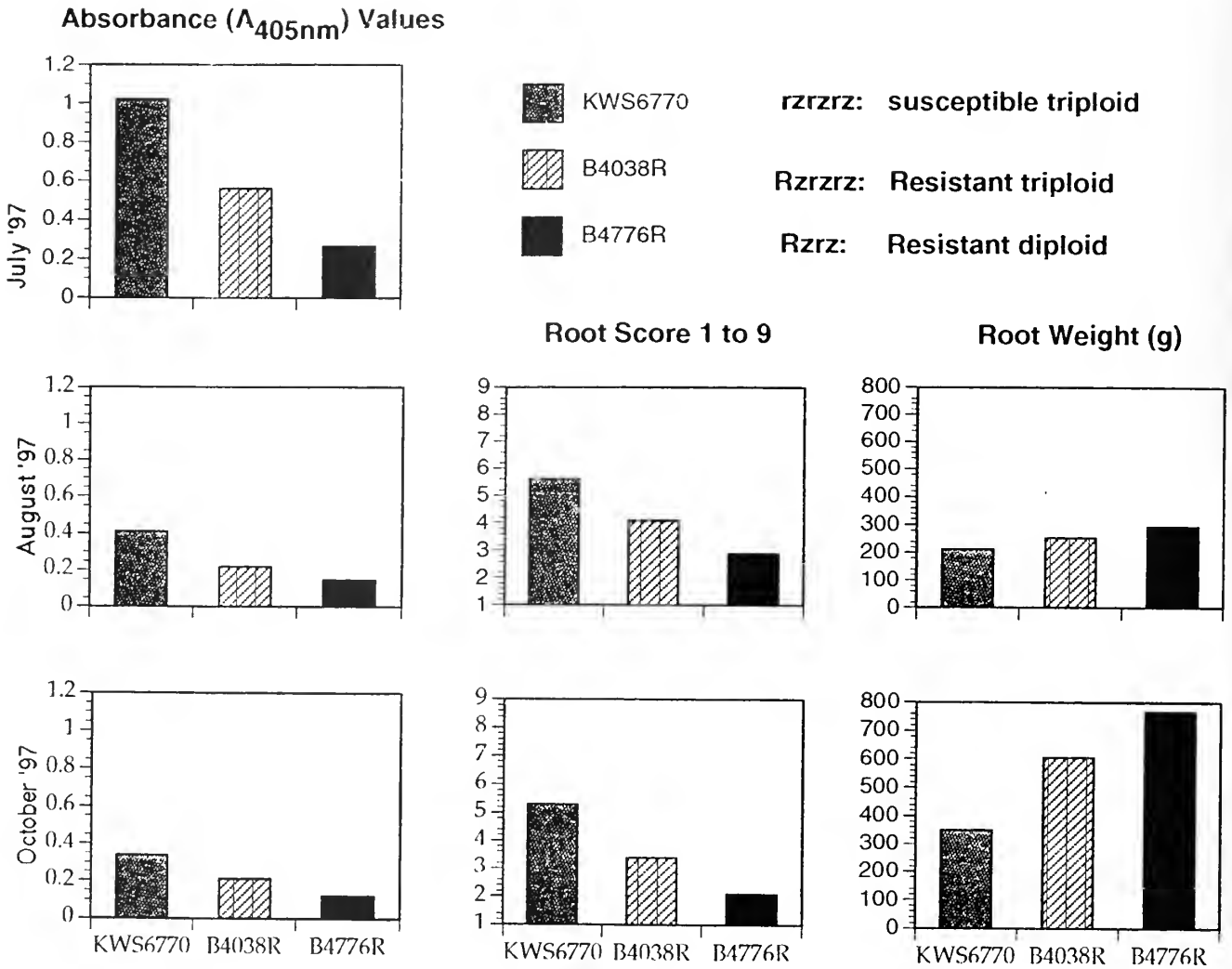

Fig. 3. Three cultivars which range from uniformly susceptible (*rzrzrz*; KWS6770) to diploid resistant (*Rzrz*; Beta4776R) to triploid resistant (*Rzrzrz*; Beta4038R) for beet necrotic yellow vein virus (BNYVV) were chosen to illustrate the association between dosage of the *Rz* allele and three variables which were measured in this study, including absorbance in TAS-ELISA for BNYVV at $A_{405\ nm}$, rhizomania root score and root weight. A highly negative correlation was observed between an increasing dosage of the *Rz* allele and absorbance values for BNYVV for the three harvest dates. For the last two harvest dates, a negative correlation was observed between allelic dosage and root score, whereas a highly positive correlation was observed between allelic dosage and root weight.

Decline in Sugar Beet Yield in the Central United States: Possible Causes, Management, and Future Studies

Gail C. Wisler
USDA-ARS, Salinas, CA

Introduction

A significant decrease in sugarbeet yield has been observed throughout the Eastern Slopes of the United States for the past few years. Possible causes which have been suggested include Rhizomania, selections of sugarbeet varieties which are not suited to the area in production, or soil-borne fungal, bacterial, and other viral pathogens.

The objectives of this study during 1998 were: (i) to determine if any soil-borne pathogens are associated with the decline in sugarbeet production in affected fields, and (ii) to determine if abiotic agents are responsible for the yield decline.

Part I. Germination rates, soil chemistry, and assays for fungal or bacterial organisms.

Materials and Methods

Eight seed sources used in the assays were representative of the varieties planted in recent years throughout the affected region (Table 1). In addition, USH11 was used as a variety that is susceptible to soil-borne furoviruses including beet necrotic yellow vein virus (BNYVV; the cause of Rhizomania), beet soil-borne mosaic virus (BSBMV) and beet soil-borne virus (BSBV).

Table 1. Sugar Beet Hybrids Used in Soil Assays Salinas, California, 1998

Identification	Lot ID
USH11	none
Beta4776R	4776.6102
HM9155	7M4234
HM-D2	3M4408
SX Monohikari	7039
Beta 1399	L1399.5322
Beta4038R	6KJO190
Crystal 205	7-11

Soil samples from 25 fields were collected for analysis. These soils originated from fields where yield decline had been documented, as well as an unaffected field, and one which had previously been identified as being infested with Rhizomania. Soil from the USDA-ARS research station in Salinas, California were also used as a rhizomania positive control. Pasteurized river sand was used as a negative control. Approximately 100 seeds of each variety were planted in 4" pots in a standard Rhizomania assay. This consisted of mixing each soil sample with an equal volume of pasteurized river sand, which were then used to fill sterile plastic pots. Pots were maintained in a greenhouse with temperatures ranging from 68-80 F. Pots were evaluated for germination rates, symptom expression, and were harvested after six weeks. Roots were washed free of soil and used for the fungal, bacterial, and viral assays.

Results

The first thing that was noticed in the soil assay was the extremely poor germination rates for several of the soil samples (Table 2). Soil samples were not received all at the same time, nor did our rhizomania greenhouse accomodate the number of samples received, so planting was staggered over time. However, the germination rates and symptoms of yellowing and distortion of seedlings were observed over the entire period of time samples were planted. As a check, some of the same soils which had shown poor germination rates and yellow symptoms were planted several times throughout the year. In addition, each time a set of soils were set up in the greenhouse, pasteurized river sand was also planted with the same eight varitieis. None of the problems with germination or symptom expression was observed in the pasteurized river sand, indicating that some factor in the soil samples from the test samples was contributing to the effects observed. Symptoms observed were suggestive of extremely low levels of residual herbicide. These levels are low enough that a chemical analysis would not likely produce any measurable data, whereas planting with sugarbeet seedlings is more sensitive. The identity of the compound which may be responsible for these symptoms, however, cannnot be ascertained by this method.

Three soil samples which showed some of the lowest germination rates and yellowing symptoms (R. Hoff, L. Green, Maser) were submitted to the Soil Control Lab in Watsonville, California for a standard soil assay, including pH and nutrient levels. Nothing in the soil analysis indicated any parameter that was out of the normal range for soil from these areas. The pH ranged from 7.7-8.0, which is normal for this area, and for sugarbeet production.

To test for fungal or bacterial organisms which may contribute to the decline in yield experienced by growers in the affected areas and to the poor germination rates observed in our greenhouse, seedlings were plated on selective media and a general medium and observed for growth of organisms. No *Pythium* sp., *Phytophthora* sp., or *Aphanomyces* sp. were found infecting these seedlings. Nor was any bacterial organism observed in these assays.

To further ascertain if any biological organism was responsible for the poor germination and yellowing effects observed, four soils which had showed poor germination and yellowing symptoms were used in a pasteurization study (Table 3). Each soil was divided, and one half was pasteurized. The pasteurized soil and soil that had not been pasteurized were each planted into SX Monohikari and UHS-11. These varieties were chosen because SX Monohikari had shown the poorest germination rates, and USH-11 had relatively high germination rates. The pasteurization study did not indicate any significant differences in the germination rates observed, and yellowing symptoms were consistent throughout this study as well.

Table 2. Germination Rates for Soil Samples : Eastern Slopes Decline 1998 [a]								
	Sugarbeet Varieties							
Field ID	Crystal 205	SX Monhikari	Beta 4038R	Beta 4776R	HM 9155	HM-D2	Beta 1399	USH-11
Meisner*	med	low	med	low	high	med	low	med
Maser*	med	low	low	med	high	low	low	med
R. Hoff*	high	low	low	low	high	low	low	med
Hoff N1/2*	med	low	med	low	high	low	low	med
Maiser*	low	low	low	low	med	med	low	low
Green*	med	low	med	low	med	med	low	high
Meisner*	high	high	high	low	low	med	low	high
Klien	high	high	high	low	high	low	high	high
Ross	high	low	high	low	med	high	high	high
Schlager	high	high	high	med	high	med	high	med
Green *	high	med	high	low	high	high	high	high
Weglin	high	high	high	low	high	high	high	low
Kaufman*	med	high	high	med	high	low	low	low
Hodge	high	high	med	low	high	high	high	high
Kaufman*	med	low	low	low	low	low	low	high
Ross*	med	low	low	low	low	low	low	med
Green*	low	low	low	low	low	low	low	low
BBAlliance*	high	low	low	med	low	low	low	med
Hodge*	high	low	high	low	med	low	low	high
M. Klien*	med	low	low	low	high	low	high	high
R. Hoff*	low	low	low	low	med	low	low	high
DS*	low	low	low	low	low	low	low	med
Keener*	high	med	high	high	high	med	med	high
Richey#1*	high	low	high	high	high	high	med	high
Rich Neb#1	high	low	low	med	high	high	low	high
Average#1*	high	high	high	med	high	high	low	high
D&C#1*	high	low	high	high	high	high	low	high
Chalk#1*	high	low	low	high	high	high	low	high
sterile sand	high	high	high	high	high	high	high	high

[a] low = 0-33% germination
med = 33-66% germination
high = 66-100% germination

*indicates soils which showed severe yellowing and distortion of seedlings.

Table 3. Effect of Pasteurization on Germination Rates for Selected Soil Samples				
Soil Sample	Pasteurized		Non-Pasteurized	
	SX Monohikari	USH11	SX Monohikari	USH11
Green*	low[a]	high	low	medium
Meisner-Gering*	low	medium	low	high
Maser*	low	medium	low	medium
Randy Hoff*	low	medium	low	medium
sterile sand	high	high	high	high

[a] low = 0-33% germination
medium = 33-66% germination
high = 66-100% germination
*indicates soils which showed severe yellowing and distortion of seedlings.

Part II: Virus assays: BNYVV, BSBMV, and BSBV

Materials and Methods

Washed roots from the greenhouse study were tested in an ELISA assay for BNYVV and BSBMV. The BNYVV test was a modified ELISA called triple antibody sandwich ELISA (TAS-ELISA) which is completely specific to BNYVV. This makes use of a polyclonal BNYVV antibody as the "trapping" antibody and a monoclonal antibody to BNYVV as the "detecting " antibody. The polyclonal antibody was a serum that was produced in our lab made from a cloned BNYVV coat protein (clone courtesy of Ken Richards) and is known to react the same was as a standard antibody from the purified virus. The advantage in this serum used is that there is an unlimited supply of antigen for antisera production, and it is a "pure" antigen, with no risk of contamination by other viruses. The BSBMV was tested in a standard double antibody sandwich ELISA (DAS-ELISA) since ther is no monoclonal antibody available for this virus.

In addition to the ELISA tests, each root sample was used to mechanically inoculate a series of indicator plants which are known to be susceptible to a wide range of sugarbeet virues. These plants consisted of: *Chenopodium quinoa*, *Nicotiana benthamiana*, *Beta vulgaris*,'USH-11', *B. macrocarpa*. Symptoms were recorded after 1-2 weeks. Leaves from symptomatic plants were retested by ELISA and also by western blot analysis for confirmation of the original diagnosis.

Since there is a limited supply of antiserum to BSBV, diagnosis was made for this virus by isolating the large, spreading necrotic local lesions characteristic of this virus on *C. quinoa*, increasing the virus, and testing each isolation using antisera to two serogroups of BSBV from Europe (antiserum courtesy of R. Koenig).

Results

Results from the virus assays are shown in Table 4. Out of 27 soil samples tested, 2 were positive for BNYVV (rhizomania), 18 were positive for BSBMV, 15 were positive for BSBV, and 9 were positive for both viruses. Twenty-four of 27 samples were positive for either BSBMV or BSBV. *Polymyxa betae* cystosori were observed in all roots tested. The reactions on indicator plants and western blot results agreed with the ELISA tests. In Table 4, those BSBV samples

shown as "positive(?)" were samples in which only mechanical inoculations were positive for BSBV, and Western blots were inconclusive. Only two fields were infested with BNYVV, and one of these was a positive control from a field which had been previously diagnosed with rhizomania.

Table 4. Virus Incidence in Soil Samples: Eastern Slopes Decline 1988[a]

Field ID	BNYVV	BSBMV	BSBV
Meisner (1-25-55)	negative	positive	negative
Maser(25-22-54)	negative	positive	positive
R. Hoff	negative	negative	positive
Hoff N1/2 (12-23-56)	negative	positive	positive
Maiser	negative	negative	positive
Green	negative	positive	positive
Meisner (27-21-55)	negative	positive	negative
Klien (35-23-55)	negative	positive	negative
Ross (18-21-56)	negative	positive	positive (?)
Schlager (29-22-53)	negative	positive	positive (?)
Green (6-25-47)	negative	positive	negative
Weglin (18-21-55)	negative	positive	positive (?)
Kaufman (7-21-56)	negative	positive	negative
Hodge (20-22-53)	negative	negative	positive (?)
Ross (18-21-55)	negative	positive	positive
Green	negative	positive	negative
BBAlliance	negative	positive	negative
Hodge (20-22-53)	negative	negative	negative
M. Klien (35-23-55)	negative	positive	negative
R. Hoff 12-23-56)	negative	positive	negative
DS (18-22-57)	negative	negative	negative
Keener (22-23-55)	negative	negative	negative
Richey#1	negative	positive	positive
Rich Neb#1	negative	positive	positive
Average#1	positive	negative	positive
D&C#1	positive	negative	positive
Chalk#1	negative	negative	positive
Salinas soil	positive	negative	negative
sterile sand	negative	negative	negative

[a] Virus identification was based on mechanical inoculation of indicator plants, ELISA, Western blot assays. Local lesions obtained from indicator plants were retested to confirm the original serological assay.

(?) indicates BSBV positive samples based only on characteristic reactions on indicator plants. All samples were infested with *Polymyxa betae* in the roots.

Conclusions:

Two problems were observed in the soil samples submitted for analysis in 1998. First, there was an obvious problem in the germination of the varieties in most soils tested. In addition, beet seedlings showed symptoms of yellowing and distortion which may be attributed to extremely low levels of residual herbicide. However, no definitive test is recommended for the low levels which may exist. Since growers have apparently not complained of poor stand, it may be that at the levels planted, the problems we observed may not be responsible for the decline in field production.

The other problem detected in these soil samples is a high incidence of BSBMV and BSBV in affected fields. Eighty-nine per cent (24/27) of the affected fields were infested with either BSBMV, BSBV, or both. Little is known at this time about the effects of these viruses on sugarbeet production in the United States. Small scale greenhouse trials in our greenhouses indicate that BSBMV significantly reduces growth of beets when compared to non-inoculated beets. It is likely that soils infested with either or both of these viruse would be less productive.

Future studies should repeat the testing that was accomplished in the first year, but should extend testing to additional fields. The goal should be to evaluate varieties for resistance to BSBMV and BSBV with fumigated replicate test strips as negative controls. As we identify specific fields that are infested with these viruses we can be assured of locations for test plots. This will allow the evaluation of the actual effect these viruses have on sugarbeet production. Previous studies in our laboratory have shown that BSBMV is widespread throughout the midwestern United States, and probably originated in this country. We also have shown that diversity exists among these virus isolated depending on their origin. Preliminary studies in our laboratory show that resistance to rhizomania does not confer resistance to BSBMV isolates. Thus, breeding programs may have yet another challenge for optimum virus resistance and sugarbeet production.

SUGAR BEET RESEARCH

1998 REPORT

Section B

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Colorado Agricultural Experiment Station

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Beet Sugar Development Foundation
(Projects 440, 441, 443, 903, and 904)

CONTENTS

USDA-ARS-NPA Sugar Beet Research Unit's Mission Statement

Utilize distinctive site environmental and disease-free characteristics and specifically developed team expertise to: develop new knowledge and adapt biotechnologies to modify host-pathogen relations that affect disease resistance, pathogenesis, and epidemiology in sugar beet and other plant species pertinent to sugar beet cultivation; discover new information and techniques to identify and produce genotypes exhibiting superior disease and stress tolerance and agronomic qualities; and provide new knowledge that improves production efficiency and biochemical processing characteristics of sugar beet.

USDA-ARS -NPA COLORADO-WYOMING RESEARCH COUNCIL

The Sugar Beet Research Unit is a part of the Colorado-Wyoming (CO-WY)Research Council. This Council was chartered to promote and coordinate cooperative research activities among CO-WY Council research units; and facilitate communication and interaction with the Northern Plains Director, and among research programs and units and with customers locally, regionally, nationally and internationally. The five research units listed below publish an annual compilation of research reports. Many of the units are considering or have placed these reports on individual home pages which can be accessed through the NPA home page at **www.npa.ars.usda.gov**.

Rangeland Resource Research Unit (RRRU) - Cheyenne, WY, Fort Collins, CO & Nunn, CO
MISSION STATEMENT: The mission of the Rangelands Resources Research Unit is to develop an understanding of the interrelationships of the basic resources that comprise rangeland ecosystems. Research is directed toward the development of science and technology that contributes to enhanced forage and livestock production and sustainable, productive rangelands in the Central Great Plains.

Central Plains Resources Management Research Unit (CPRMRU)- Akron CO.
MISSION STATEMENT: To enhance the economic and environmental well-being of agriculture by development of integrated cropping systems and technologies for maximum utilization of soil and water resources. Emphasis is on efficient use of plant nutrients, pesticides, and water and soil conservation/preservation.

Great Plains Systems Research Unit (GPSRU) - Fort Collins, CO.
MISSION STATEMENT: Help develop and implement sustainable and adaptive agricultural systems by: (1) synthesizing, quantifying, evaluating, and enhancing knowledge of processes; (2) developing integrated models of agricultural systems; (3) providing technology packages to agricultural communities and action agencies.

Soil-Plant-Nutrient Research Unit (SPNRU) - Fort Collins, CO.
MISSION STATEMENT: To develop and evaluate new knowledge required to efficiently manage soil, fertilizer and plant nutrients (emphasis on nitrogen) to achieve optimum crop yields, maximize farm profitability, maintain environmental quality and sustain long-term productivity.

Water Management Resources Unit (WMRU) - Fort Collins, CO.
MISSION STATEMENT: Research emphasis is to integrate applied and basic principles to develop improved water, chemical, and alternative weed management systems and irrigation system designs. Improvements are directed toward sustainable, environmentally sound and efficient systems based on soil, water, fertility, energy, and weed ecology principles. This encompasses understanding physical and biological phenomena and developing computer simulation models and precision farming systems to transfer new technologies to producers, consultants, action agencies, industry, and scientists.

For a copy of the Colorado-Wyoming (CO-WY)Research Council Annual Report or information on any of these programs, please note the following contacts:

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EVALUATION OF CONTRIBUTED LINES FOR RESISTANCE TO *RHIZOCTONIA SOLANI*, A CAUSAL FUNGUS OF SUGAR BEET ROOT ROT. (BSDF Project 903)

L. Panella

Annually, for over thirty years, the breeding program in Fort Collins has created an artificial epiphytotic through inoculation with *Rhizoctonia solani* to evaluate and select for resistance to root rot caused by this pathogen. We have been pleased to participate and lead this cooperative research project between the ARS, Colorado State University, and the BSDF. The project primarily involved field studies conducted on 35 acres of leased land near Windsor, CO. Randomized, complete-block designs with five replicates were used to evaluate Fort Collins ARS breeding germplasm. Rhizoctonia-resistant line FC703 and highly susceptible FC901/C817//413 were included as internal controls, along with highly resistant FC705-1.

One-row plots, planted May 21st, were 12 feet long with 22 inches between rows and 8-10 inches within-row spacing. Inoculation with dry, ground, barley-grain inoculum of *Rhizoctonia solani* isolate R-9 was performed on July 20; immediately after inoculation, a cultivation was performed so as to throw soil into the beet crowns. The field was sprayed twice with Betamix Progress, Upbeet, and Stinger (May 27 and June 5) to control weeds. The field was thinned by hand and irrigated as necessary - it was a dry summer (see weather data in Figure 1). Any additional weed control was by hand hoeing and the plots were thinned to 8 in spacing between beets starting about 6 wk after planting.

Table 1. 1998 Rhizoctonia Root Rot Nursery, Fort Collins, CO. The Graph in Figure 1 summarizes the 1998 weather data for our Rhizoctonia Root Rot Nursery in 1998. The table below presents summary data of the entire nursery. The experiment mean, the mean of the susceptible check, the mean of the resistant check, and the mean of the highly resistant check are given for each of the experiments in the nursery. LSD is at the t=0.05 level.

	Disease Index					Percent Healthy (classes 0 & 1)					Percent in Classes 0 to 3				
Exp.	Mean	Sus.	Res.	H Res.	LSD	Mean	Sus.	Res.	H Res.	LSD	Mean	Sus.	Res.	H Res.	LSD
1R	6.01	6.04	4.34	4.44	0.76	1.01	0.00	5.31	8.30	7.0	4.66	0.00	37.33	29.14	11.5
2R	5.81	5.33	3.47	4.50	1.12	5.74	0.00	34.50	0.00	11.0	12.20	0.00	41.83	29.36	17.9
3R	4.78	5.55	2.76	3.38	1.27	8.69	0.00	36.00	33.75	16.7	21.82	9.00	60.27	45.00	25.4
7R	5.51	5.75	4.75	4.68	1.09	3.84	0.00	0.00	13.28	10.6	15.92	9.00	33.75	20.96	17.9
8R	5.21	5.69	1.50	4.81	0.93	3.25	0.00	53.30	8.30	11.7	10.71	0.00	90.00	24.16	14.9
Avg.	**5.47**	**5.67**	**3.36**	**4.36**		**4.51**	**0.00**	**25.82**	**12.73**		**13.06**	**3.60**	**52.64**	**29.72**	

Percent in Classes is the transformed value (arcsin-square root)
Mean = Experiment Mean;
Sus. = Susceptible Check;
Res. = Resistant Check (FC703);
H Res. = Highly Resistant Check (FC705/1)

Beets were harvested August 19 through 21. Each root was rated for rot on a scale of 0 to 7 (dead) as previously described. ANOVAs were performed on disease indices (DIs), percent healthy roots (classes

0 and 1 combined), and percentage of roots in classes 0 thru 3 (those most likely to be harvested and taken to the factory). Percentages were transformed to arcsin-square roots to normalize the data for analyses ("APHLTHY" and "AP 0-3" in the accompanying table). LSDs (P = 0.05) are provided for comparing DIs and arcsin transformations among entries and with our internal checks.

The 1998 Rhizoctonia epidemic started strong and progressed quickly, becoming severe by mid August. We had to irrigate the beets up and had a period of cold temperature with just a little rain in the week after planting (see accompanying summary of weather data in Figure 1). Therefore, stands were poor, and, in some instances, we lost plots to lack of germination and crusting. Differences in DIs among entries in all tests were highly significant ($P < 0.0001$). Mean DIs across all tests for highly resistant FC705-1, resistant FC703, and highly susceptible FC901 controls were 4.4, 3.4, and 5.7, respectively (see Table 1). Percentages of healthy roots were 12.7, 25.8, and 0.0 for these controls. Percentages of roots in disease classes 0 thru 3 were 29.72, 56.6, and 3.6, respectively. The highest and lowest DIs for contributor lines were 7.0 and 3.5, respectively.

USDA-ARS 1998 Rhizoctonia Disease Nursery, Windsor, CO.

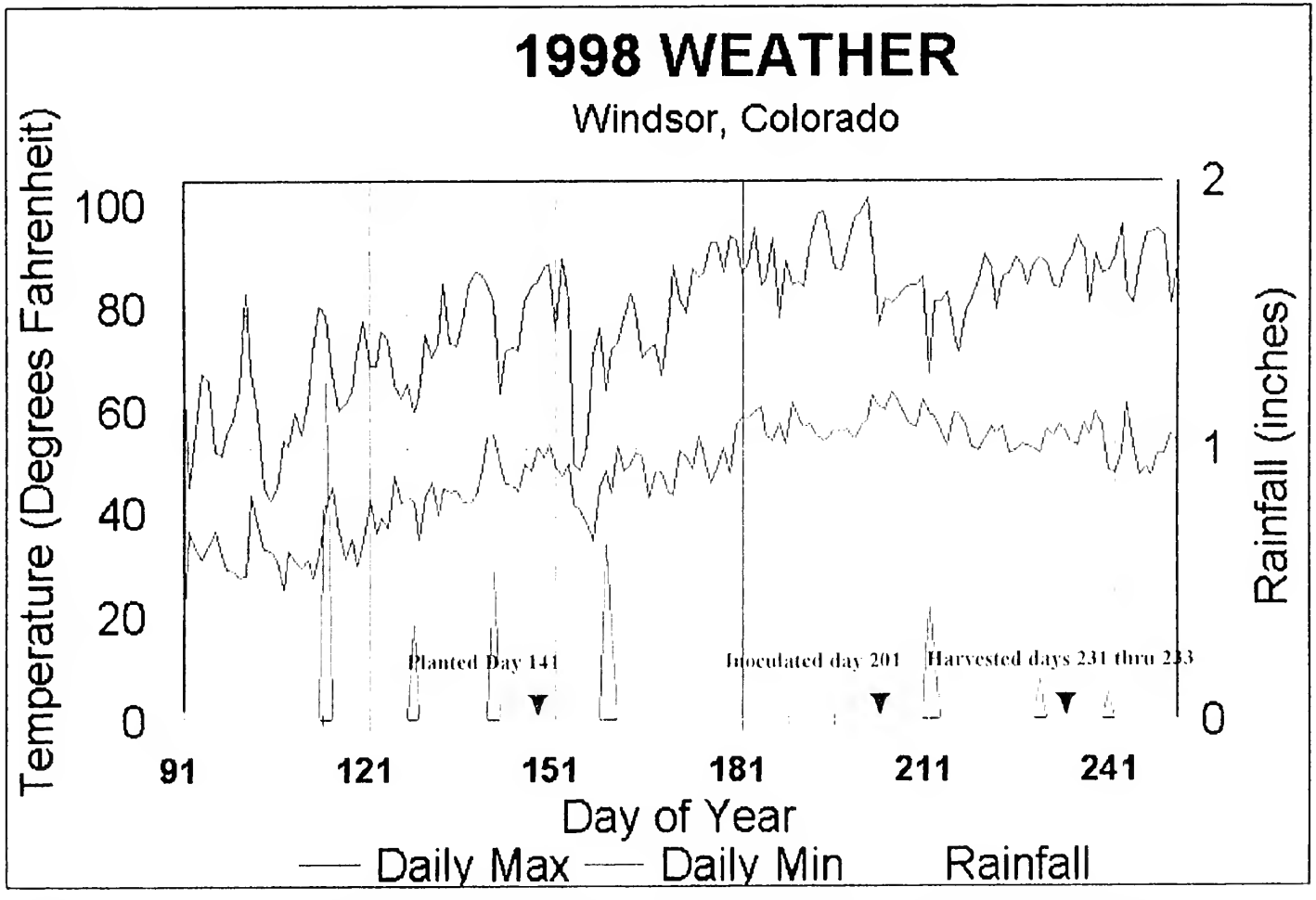

Figure 1. Weather Data was received from Colorado's CoAgMet system, which is electronically reported, and can be accessed off of the Colorado Climate Center Webstite which can be reached at the following URL - **http://ulysses.atmos.colostate.edu/** The Lucerne weather station is located one quarter mile southwest of Lucerne, Colorado (Lat = 40.4753, Lon = 104.7075, elevation = 4750). Our Windsor plots are located about 10 miles west of Lucerne (about Latitude = 40.2730, Longitude = 104.5500, elevation = 4800). The Rhizoctonia root rot nursery was planted on day 141 (May 21), inoculated on day 201 (July 20) and evaluated on days 231 through 233 (August 19 - 21).

EVALUATION OF CONTRIBUTED LINES FOR RESISTANCE TO *CERCOSPORA BETICOLA*, CAUSAL FUNGUS OF CERCOSPORA LEAF SPOT (BSDF Project 904)

L. Panella

The breeding program in Fort Collins has created an artificial epiphytotic through inoculation with *Cercospora beticola* annually for over forty years to evaluate and select for resistance to leaf spot caused by this pathogen. We have been pleased to participate and lead this cooperative research project between the ARS, Colorado State University, and the BSDF. The project primarily involved field studies conducted on 35 acres of leased land near Windsor, CO.

Randomized complete-block designs, with three replications were used to evaluate breeding germplasm. Internal controls included a highly susceptible synthetic and a resistant check (FC 504/ 502-2//SP6322-0). The nursery was planted on April 29th. Fertilization was 75% of the soil test recommendation to minimize leaf growth, which can interfere with visual evaluations. Two-row plots were 12 feet long, with 22-inch row spacing and an 8 - to 10-inch within-row plant spacing. Inoculation was performed on July 6th and again on July 13th. Evaluations were made on August 25, September 3, and 8, with the peak of the epidemic occurring on or about the last date. The field was sprayed twice with Betamix Progress, Upbeet, and Stinger (May 27 and June 5) to control weeds. The field was thinned by hand and irrigated as necessary - it was a dry summer (see summary of weather data Figure 2).

Table 2. 1998 Cercospora Leaf Spot Nursery, Fort Collins, CO. The Graph in Figure 2 summarizes the 1998 weather data for our Cercospora Leaf Spot Nursery int 1998. The table below presents summary data of the entire nursery. The experiment mean, the mean of the susceptible check, and the mean of the resistant check are given for each of the experiments in the nursery, for each evaluation date. The highest mean rating given on September 8th was an 8.0 and the lowest a 2.50.

	August 25th Disease Index				September 3rd Disease Index				September 8th Disease Index			
Exp.	Mean	Sus.[1]	Res.[2]	LSD	Mean	Sus.	Res.	LSD	Mean	Sus.	Res.	LSD
1A	3.65	5.17	2.33	1.14	3.65	4.33	2.17	0.86	4.11	4.67	2.67	0.76
2A	4.61	5.25	3.00	0.92	4.80	5.00	3.25	1.29	5.23	5.00	3.50	1.09
3A	3.19	4.00	2.67	0.70	3.22	4.17	2.67	0.87	3.80	4.50	3.17	0.96
4A	4.05	5.33	2.50	0.89	4.02	4.67	3.17	0.74	4.40	5.00	3.50	0.86
5A	4.99	5.67	2.33	0.94	5.05	5.50	2.83	0.91	5.36	6.33	3.17	1.04
6A[3]	4.16	5.00	2.75	1.11	4.34	5.50	3.25	1.32	4.83	5.50	3.75	1.23
7A	4.52	5.67	2.50	0.89	4.62	5.83	2.83	0.98	4.76	5.33	3.17	0.87
8A	2.65	6.00	1.67	1.04	2.96	5.67	2.17	0.88	3.59	5.83	2.83	0.97
10A	4.58	5.50	2.50	0.85	4.78	5.33	2.50	0.88	5.15	5.83	2.67	1.18
Mean	**4.04**	**5.29**	**2.47**		**4.16**	**5.11**	**2.76**		**4.58**	**5.33**	**3.16**	

[1]Cercospora Susceptible Check - SP351069-0
[2]Cercospora Resistant Check - FC 504CMS/FC 502-2//SP6322-0
[3]There were only two replications of Experiment 6A

The 1998 leaf spot epidemic started strong and progressed rather slowly, but eventually became more severe by late August. We had a period between of about one month right after inoculation, in which we had relatively high evening temperatures (see accompanying summary of weather data), which helped disease development. An analysis of variance (PROC ANOVA - SAS)

on the disease indices (visual evaluation scores) determined that there were significant differences among entries (P=0.05) on all three dates. At our third evaluation, means of the resistant and susceptible internal controls were 3.2 and 5.3 (scale of 0-10), respectively, across the nursery. In 1997 (September 8), these means were 3.7 and 7.3, respectively (see Table 2). Means of contributor lines on September 8 ranged from 2.5-8.0, compared with 4.3-8.3 in the severe epidemic of 1997.

USDA-ARS 1998 Cercospora Disease Nursery, Windsor, CO.

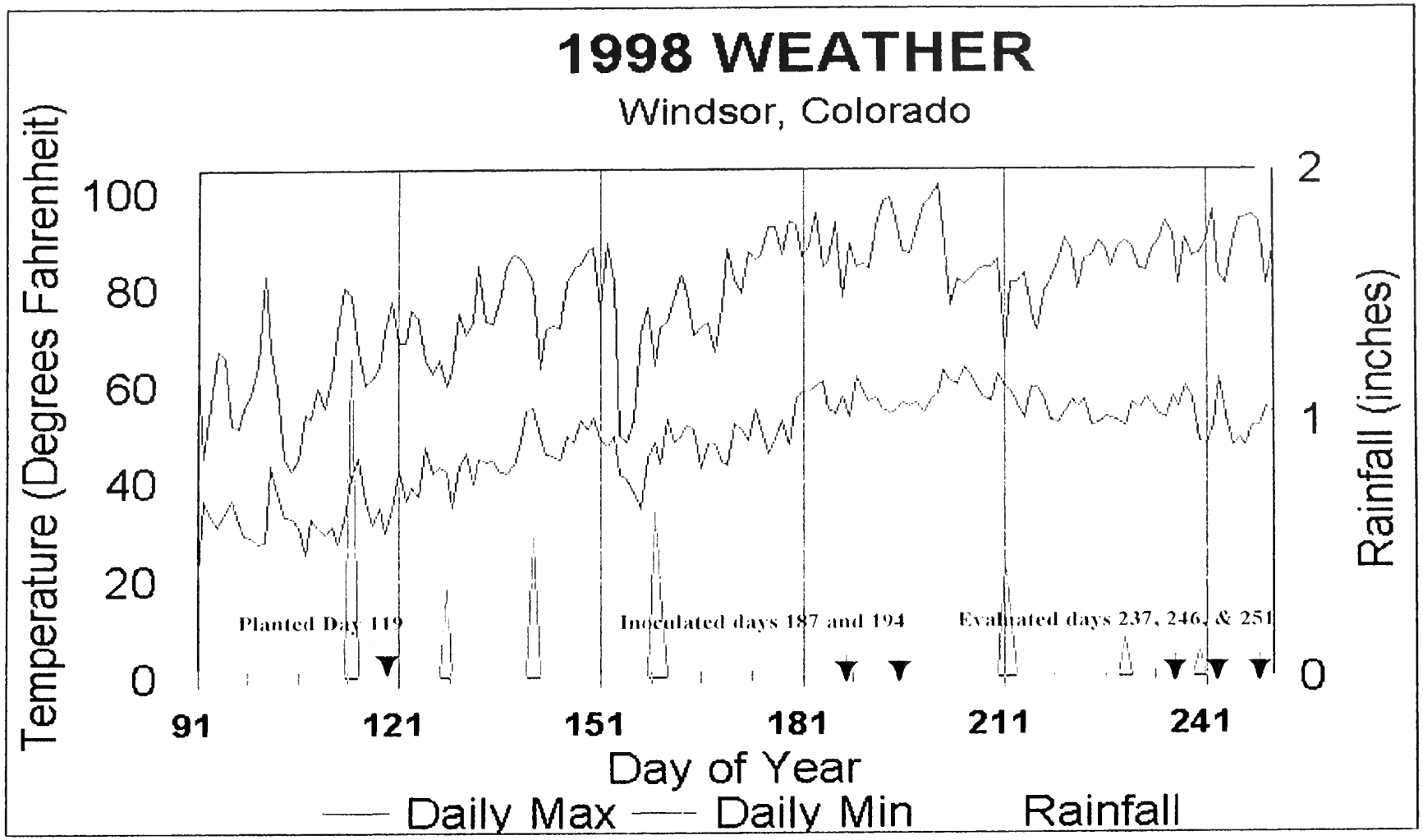

Figure 2 Weather Data was received from Colorado's CoAgMet system, which is electronically reported, and can be accessed off of the Colorado Climate Center Webstite which can be reached at the following URL - **http://ulysses.atmos.colostate.edu/** The Lucerne weather station is located one quarter mile southwest of Lucerne, Colorado (Lat = 40.4753, Lon = 104.7075, elevation = 4750). Our Windsor plots are located about 10 miles west of Lucerne (about Latitude = 40.2730, Longitude = 104.5500, elevation = 4800). The Cercospora leaf spot nursery was planted on day 119 (April 29), inoculated on days 187 & 194 (July 6 & 13) and evaluated on days 237, 246, & 251 (August 25, September 3 & 8).

RHIZOCTONIA ROOT ROT RESISTANCE AND DEVELOPMENT OF GENETIC RESISTANCE IN SUGAR BEET - BSDF Project 440

L. Panella

This facet of the USDA-ARS Fort Collin's sugar beet breeding program has as its goals: 1) the understanding the genetics of the *Rhizoctonia solani*/sugar beet interaction in order to better facilitate development of germplasm with high levels of resistance to Rhizoctonia and other sugar beet diseases, and 2) to provide the knowledge to better manage this disease in sugar beet production areas. It is an integrated research program with greenhouse, laboratory, and field components. Genetic information developed previously in our research is used to execute additional cycles of pathogen inoculation, plant selection, and recombination among germplasms that we have in our cyclic improvement program. Germplasms in various stages of improvement are evaluated for resistance in inoculated field tests. Results of these tests form the basis of decisions about specific germplasm, i.e., retain, shelve, discard, recombine, release, etc. Germplasms likely to be useful for variety improvement are identified and released for use by other sugar beet breeders.

1998 Field Research on Rhizoctonia Root Rot of Sugar Beet.

The breeding program in Fort Collins has created annually an artificial epiphytotic through inoculation with *Rhizoctonia solani* for over thirty years to evaluate and select for resistance to root rot caused by this pathogen. We have been pleased to participate and lead this cooperative research project between the ARS, Colorado State University, and the BSDF. The project primarily involved field studies conducted on 35 acres of leased land near Windsor, CO. Randomized, complete-block designs with five replicates were used to evaluate Fort Collins ARS breeding germplasm. *Rhizoctonia*-resistant line FC703 and highly susceptible FC901/C817//413 were included as internal controls, along with highly resistant FC705-1.

One-row plots, planted May 21st, were 14 feet long with 22 inches between rows and 8-10 inches within-row spacing. Inoculation with dry, ground, barley-grain inoculum of *Rhizoctonia solani* isolate R-9 was performed on July 20; immediately after inoculation, a cultivation was performed so as to throw soil into the beet crowns. The field was sprayed twice with Betamix Progress, Upbeet, and Stinger (May 27 and June 5) to control weeds. The field was thinned by hand and irrigated as necessary - it was a dry summer (Figure 1). Any additional weed control was by hand hoeing and the plots were thinned to 8 in spacing between beets starting about 6 wk after planting.

Beets were harvested August 19 through 21. Each root was rated for rot on a scale of 0 to 7 (dead) as previously described. ANOVAs were performed on disease indices (DIs), percent healthy roots (classes 0 and 1 combined), and percentage of roots in classes 0 thru 3 (those most likely to be harvested and taken to the factory). Percentages were transformed to arcsin-square roots to normalize the data for analyses ("APHLTHY" and "AP 0-3" in the accompanying table). Both percentages and arcsin transformations are given in Tables 3 & 4. LSDs (P = 0.05) are provided for comparing DIs and arcsin transformations among entries and with our internal checks.

The 1998 Rhizoctonia epidemic started strong and progressed quickly, becoming severe by mid August. We had to irrigate the beets up and had a period of cold temperature with just a little rain in the week after planting (see accompanying summary of weather data in Figure 1). Therefore, stands were poor, and, in some instances, we lost plots to lack of germination and crusting.

Allotment of Fort Collins "FC" numbers (3-digit numbers)

"FC" numbers are "convenience" numbers for "seed releases" or purposes where a permanent line designation is needed — i.e. a number that does not change from generation to generation where little or no selection pressure is applied. Initially, an "FC" no. was written thus "FC 501" [now FC727], "FC 502 CMS" [now FC715CMS], etc. Sublines (from selfing) were designated thus, "FC 502/2" [now FC709-2], "FC502/3" [now FC502-3], etc. The same applys when the line is substantially changed by selection without selfing.

Below 500	Originally LeRoy Powers - now parental lines and special genetic stocks.
500's	Leaf Spot Resistant (LSR), Type-O lines & male steriles [CMS]
600's	LSR-Curly Top Resistant (CTR), type-O lines & male steriles [CMS]
700's	Rhizoctonia Resistant
800's	LSR-CTR-Rhizoctonia resistant
900's	Pollinators, LSR-CTR type

Differences in DIs among entries in all tests were highly significant ($P < 0.0001$). Mean DIs across all tests for highly resistant FC705-1, resistant FC703, and highly susceptible FC901 controls were 4.4, 3.4, and 5.7, respectively. Percentages of healthy roots were 12.7, 25.8, and 0.0 for these controls. Percentages of roots in disease classes 0 thru 3 were 29.72, 56.6, and 3.6, respectively. The highest and lowest DIs for contributor lines were 7.0 and 3.5, respectively.

Transforming Rhizoctonia-Resistant Populations to Germplasm with Multiple Disease Resistance

Root rot and leaf spot are two serious diseases of sugar beets caused by fungi (*Rhizoctonia solani* and *Cercospora beticola*, respectively). The diseases caused by these fungi may produce a severe reduction of yield in many sugar beet production areas. Cultural control measures are not adequate by themselves, and often no chemicals are registered for control of these diseases, or chemical control is expensive or environmentally unsafe. Increased levels of genetic resistance in sugar beet varieties are needed to minimize growers' losses from these diseases. In a hybrid crop like sugar beets, it is preferable that all of the parents contain some level of resistance to diseases prevalent in the area in which the hybrid is to be grown. Multiple disease resistance is a difficult goal in a crop improvement program, especially when working with an outcrossing species. In alternating generations of selection, some of the progress made in resistance to one disease is lost while selecting for resistance to other diseases.

One way of solving the problem of selecting for multiple disease resistance is the use of progeny testing. By testing the progeny of individual mother roots, plants with multiple disease resistance can be identified and used as parents of the next generation. The most efficient use of progeny testing is when the genotype of both parents is controlled, and the most effective way to do

this is through self-pollination. In sugar beet, there is a dominant, self-fertility gene that permits self-pollination. Used in conjunction with genetic male sterility, to insure cross pollination, a system of selfed-family progeny testing can be utilized.

This effort is based on the Rhizoctonia-resistant materials from the programs of John Gaskill and Richard Hecker, and disease resistant germplasm from other sources to produce germplasm highly resistant to Rhizoctonia solani. This base of Rhizoctonia-resistant germplasm is being combined with material from the USDA-ARS breeding programs at Salinas and Fargo, as well as with sources for higher yield and sucrose. The Salinas material has the self-fertility allele, is segregating for genetic male sterility, and also contains a broad spectrum of resistance to diseases of importance in California as well as other sugar beet production areas (including rhizomania, powdery mildew, virus yellows, and curly top virus). Fargo sources of root maggot and Cercospora leaf spot resistance are also being utilized.

A number of source populations are being developed. The germplasm, FC712(4X) is being released in 1999. This germplasms was developed in our research project that has been contributed to, in kind, by the Beet Sugar Development Foundation. The soon to be released tetraploid pollinator germplasm combines excellent Rhizoctonia-root-rot resistance with a good level of leaf spot resistance. Germplasms whose development was begun under the breeding program of Dr. Richard Hecker are still being evaluated in the field. These germplasms and other germplasms from the Fort Collins program were field-tested in summer of 1998 for resistance to *R. solani* (Tables 3-4), *C. beticola* (Tables 5-6), and the curly top virus (Table 7). More germplasms that were selected for increased resistance to Rhizoctonia-root-rot in 1996, and tested in 1997, will be tested again in 1998; and the most promising of these will be released in the future.

There currently are four major groups of Rhizoctonia-resistant germplasms currently under development.

1. Germplasms developed in Dr. Hecker's breeding program for resistance to Rhizoctonia root rot and Cercospora leaf spot are being field tested and selected in the Rhizoctonia root rot nursery at Fort Collins (also in the Cercospora leaf spot and curly top nurseries).

2. Rhizoctonia-resistant monogerm polycross base population developed by a cross between FC708 and two Salinas germplasms, 2890 and 2859.

   A. 2890 (sp) 0790 *mm aa* x 1890 (Salinas); is seed from *aa* plants open pollinated by A- plants. 0790 = population-790 cycle 5 synthetic by S_1 progeny, M.S. mm, O-type, good combining ability, adapted to California, S^f,. 1890 = BC population to population 790 to get Rz equivalent, remains variable for M-:mm, Rz-:rzrz, etc.
   B. 2859 m (sp) = 1859, 1859R aa x A- (Salinas); Released in 1992 as C859. S^f, similar to 2890, but should have higher curly top resistance (CTR). Segregates and variable for M-:mm, Rz-:rzrz, A-:aa, predominant background is lines like C563, which is widely used in western USA as source of CTR, mm, O-type.

3. Rhizoctonia root rot resistance multigerm base population developed by a cross between FC709-2 and a Salinas germplasms, 2915.
   A. 2915 (sp) RZM 1915-#m 1913-# aa x A (Salinas); Seed harvested from aa (ms) plants open-pollinated by A- (fertile) plants. This population will segregate for A-:aa, Rz-:rzrz, s^ss^s:s^f-,

(>½ s^f), R-:rr, It will be multigerm, have moderate to good tolerance to virus yellows, curly top, bolting, Erwinia; variable for reaction to powdery mildew, production traits. Individual plants will be either As or aa. Background of population is mostly from OP, MM lines such as C46, C37.

4. Combination Rhizoctonia root rot and Cercospora leaf spot resistant multigerm pollinator population from FC907 (out of Fargo) and FC709-2.

Progress in 1998

0.1. Selections have been made in these populations and they have been crossed with other germplasm in a continuing Rhizoctonia-resistance breeding effort. Two multigerm pollinators (FC709-2 and FC727) with Rhizoctonia and Cercospora resistance were released this winter and FC712 4(X) will be this summer. It has excellent resistance to Rhizoctonia root rot and good Cercospora resistance. Monogerm O-type lines and CMS equivalents, selected in the 1996 Rhizoctonia nursery were tested this year and will be crossed this winter for combining ability tests next season.

0.2. S_1 families selected for curly top resistance from this monogerm base populations were selected in the Rhizoctonia nursery last year. This germplasm has been harvested increased in the Greenhouse at Fort Collins. This seed was planted in the mother root nursery at Fort Collins for increase and it will be tested in Salinas next year to see if the Holly gene for Rhizomania resistance is still segregating in the population. Seed also will be planted in the Rhizoctonia nursery next year and again selected for resistance.

0.3. Individual selfed & half-sib families were harvested and progeny tested in the Rhizoctonia and curly top nursery in 1998 and Rhizoctonia nursery this year. Selections were made from the Rhizoctonia nursery and remnant seed is available for the top performers in the curly top nursery. These selections will be recombined and tested next year and the following year.

0.4. Seed, increase from Rhizoctonia-resistant selected roots of FC907 ((FC701 x FC607)BC_4), was tested in the Rhizoctonia and Cercospora nurseries next year. Selections made in a (FC709-2 x FC907)F_2 population were increased in the greenhouse last winter and will be tested in the Rhizoctonia and Cercospora nurseries this year.

The collaborative project with the Plant Genetic Resources Conservation Unit at Griffin, GA has been completed. The results are being prepared for publication. Meanwhile, we are looking for short, unique sequences within the ITS regions that can be used to "fingerprint" isolates of *R. solani* that are pathogenic on sugar beet.

Future laboratory research will use the information gained from studying the pathogen to begin to look at the sugar beet reaction to the *Rhizoctonia* pathogen. Biocontrol work will resume once a new Research Plant Pathologist is on board.

Table 3. Experiment 9R, 1998. Rhizoctonia Resistance Evaluation of USDA-ARS Breeding Lines from Fargo (Smith and Campbell) and East Lansing (Saunders & Halloin)

Seed Source	Description	DI[1]	% Hlthy[2]	% 0 - 3-[3]	Z%[4] Hlthy	Z% 0 - 3
	LSD[5]	1.1			ns	24.2
921024	FC709-2 - Fort Collins release (+ 2 cycles Rhizoc & 1 cycle sucrose)	2.6	4	96	7	85
751080H	FC703 - Resistant Check	3.2	5	77	7	67
881032H	FC712 - Fort Collins Release	3.4	3	77	4	65
951017	FC727 -Fort Collins release (FC703/(AJ-ZZ & Aula Dei & 67-436), MM)	3.5	8	62	11	56
831083	FC705/1 - Highly Resistant Check	3.8	0	55	0	50
7	B K 736 - John Halloin - East Lansing	4.3	0	22	0	22
98J26-052	East Lansing - Joe Saunders	4.4	3	31	5	31
3	ACH 1353 - John Halloin - East Lansing	4.4	9	32	10	30
4	HMA 2733 - John Halloin - East Lansing	4.5	3	27	4	31
8	SX 1217 - John Halloin - East Lansing	4.8	0	25	0	28
6	HMA RH3 - John Halloin - East Lansing	4.9	5	20	7	26
5	HMA 2736 - John Halloin - East Lansing	5.2	2	14	4	19
96N0009	Fargo - Low Amino-n (FC504cms/FC502-2//605 /3) high sucrose LSR multigerm pop.	5.3	0	21	0	24
96N0012	Fargo - Low Sodium selection	5.5	0	5	0	7
9	ACH 308 - John Halloin - East Lansing	5.6	1	15	4	17
97N0132	F1015 - Fargo release	5.8	7	16	7	18
10	B 5931 - John Halloin - East Lansing	5.8	0	6	0	9
931017	(FC901/C817)//413 - Susceptible Check	5.8	0	9	0	14
11	HMA E17 - John Halloin - East Lansing	5.8	0	7	0	11
96N0011	Fargo - Low Potassium selection	5.8	4	8	5	8
12	US H20 - John Halloin - East Lansing	5.9	0	6	0	9
96N0051	F1016 - Fargo release	6.2	0	2	0	4

[1]Disease Index is based on a scale of 0 (=healthy) to 7 (= plant dead).
[2]Percent of healthy roots (disease classes 0 and 1 combined).
[3]Percent of diseased roots likely to be taken for processing (disease classes 0 through 3 combined).
[4]Percentages were transformed to arcsin-square roots to normalize the data for analyzes.
[5]α=0.05.

Table 4. Experiment 4R, 1998. Rhizoctonia Resistance Evaluation of USDA-ARS Breeding Lines from Fort Collins CO, (Lee Panella)

Seed Source	Description	DI[1]	% Hlthy[2]	% 0 - 3-[3]	Z%[4] Hlthy	Z% 0 - 3
	LSD[5]	1.7	33	100	33	90
971017	FC 712 colchicine doubled - FC712(4X)	2.0	42	86	40	73
96RR	Joe Saunders - East Lansing	2.1	44	89	39	76
881032H	Fort Collins Release - FC712	2.2	45	78	40	70
971018	FC710 colchicine doubled - FC710(4X)	2.3	47	83	41	71
961014	FC702/LSR-CTR - FC724	2.5	27	76	30	64
891033	FC710	2.5	37	67	38	56
961015	C718/(C718/FC708) - FC720	2.5	28	75	29	64
951017	Fort Collins release (FC703/(AJ-ZZ & Aula Dei & 67-436), MM) - FC727	2.6	33	83	29	72
921024	Fort Collins release (+ 2 cycles Rhizoc & 1 cycle sucrose) - FC709-2	2.7	33	66	31	58
831083	Highly Resistant Check - FC705-1	3.1	16	76	18	65
961012HO	FC712/Mono-Hy A4	3.2	16	52	17	46
921019	FC712/A4, 3 cycles Rhizoc, MM - FC729	3.7	11	51	12	45
961012HO1	FC712/Mono-Hy A4	3.9	12	39	13	38
751080H	Resistant Check - FC703	4.2	11	41	12	36
951016HO	EL44/FC708 mm - FC723	4.2	4	24	5	26
951016HO1	EL44/FC708 CMS - FC723CMS	4.2	0	30	0	29
961010HO1	C718/FC708 - FC722CMS	4.3	7	11	7	12
961021		4.4	9	18	12	19
981009H	(907/709-2)F2-Sel Rhzc	4.5	0	40	0	36
961010HO	C718/FC708 - FC722	4.5	2	21	4	23
SR87	SR87 - Joe Saunders - East Lansing	4.6	0	15	0	19
961011HO1	FC607/FC708	5.5	0	6	0	9
931017	Susceptible Check - (FC901/C817)//413	5.5	2	6	4	11
971020	FC607/FC701 BC4 - FC907-1	5.6	0	13	0	11
961011HO	FC607/FC708	6.1	0	3	0	4
97J09-00	Joe Saunders - East Lansing					

[1]Disease Index is based on a scale of 0 (=healthy) to 7 (= plant dead).
[2]Percent of healthy roots (disease classes 0 and 1 combined).
[3]Percent of diseased roots likely to be taken for processing (disease classes 0 through 3 combined).
[4]Percentages were transformed to arcsin-square roots to normalize the data for analyzes.
[5]Because there were unequal cell sizes (missing plots) an LSD is not an appropriate comparison.

CERCOSPORA LEAF SPOT RESEARCH AND BREEDING FOR CERCOSPORA AND CURLY TOP RESISTANCE - (BSDF Project 441)

L. Panella

This element of the breeding program at Fort Collins is devoted to the development of germplasm with resistance to more than one sugar beet disease and improved agronomic characteristics. It is built on germplasm developed at Fort Collins over the last fifty years for combined resistance to Cercospora leaf spot and the curly top virus. This is an integrated breeding program with greenhouse and laboratory studies, and a field program based on testing in an artificial epiphytotic created in the unique Fort Collins environment. It involves close collaboration with the other USDA-ARS sugar beet programs in the U.S. and sugar beet seed industry customers. The major goals of this program are: 1) the development of sugar beet germplasm with resistance to more than one disease and excellent agronomic characteristics; 2) the improvement of breeding techniques, traditional and molecular, to develop this germplasm; and 3) an increased understanding of the sugar beet/pathogen interactions to improve management practices of these diseases in sugar beet production areas. Genetic information developed during this research will be used to execute additional cycles of pathogen inoculation, plant selection, and recombination among germplasms that we have in our leaf spot improvement program. Results of these tests will be the basis of decisions about specific germplasm, i.e., retain, discard, recombine, release, etc. Germplasms likely to be useful for variety improvement will be identified and released for use by other sugar beet breeders.

Increased resistance to *Cercospora* continues to be an extremely important goal. If the level of resistance available in most Cercospora-resistant experimental lines were present in commercial hybrids (along with good sugar and seed yield), the need for fungicides would be greatly reduced. That continued improvement in genetic resistance to this serious pathogen is still needed is evident by the occurrence of *Cercospora* strains that are resistant or increasingly tolerant to our most potent fungicides. Additionally, some of these fungicides may be removed from the market because of their perceived or real threat to the environment. In many areas where Cercospora leaf spot is a problem, the curly top virus also causes significant losses. And, there are some growing areas in which combined resistance to Cercospora leaf spot, Rhizomania, curly top, Rhizoctonia root rot, and other diseases are desirable. Germplasm is needed with combined resistance to these diseases, along with good combining ability for yield components.

1998 Field Research on Cercospora Leaf Spot of Sugar Beet

The breeding program in Fort Collins has created an artificial epiphytotic through inoculation with *Cercospora beticola* annually for over forty years to evaluate and select for resistance to leaf spot caused by this pathogen. We have been pleased to participate and lead this cooperative research project between the ARS, Colorado State University, and the BSDF. The project primarily involved field studies conducted on 35 acres of leased land near Windsor, CO.

Randomized complete-block designs, with three replications were used to evaluate breeding germplasm. Internal controls included a highly susceptible synthetic and a resistant check, FC(504 X 502/2) X SP6322-0. The nursery was planted on April 29th. Fertilization was 75% of the soil test recommendation to minimize leaf growth, which can interfere with visual evaluations. Two-row plots were 12 feet long, with 22-inch row spacing and an 8- to 10-inch within-row plant spacing.

Inoculation was performed on July 6th and again on July 13th. Evaluations were made on August 25, September 3, and 8, with the peak of the epidemic occurring on or about the last date. The field was sprayed twice with Betamix Progress, Upbeet, and Stinger (May 27 and June 5) to control weeds. The field was thinned by hand and irrigated as necessary - it was a dry summer (see summary of weather data Figure 2).

The 1998 leaf spot epidemic started strong and progressed rather slowly, but eventually became more severe by late August. We had a period between of about one month right after inoculation, in which we had relatively high evening temperatures (see accompanying summary of weather data), which helped disease development. An analysis of variance (PROC ANOVA - SAS) on the disease indices (visual evaluation scores) determined that there were significant differences among entries (P=0.05) on all three dates (Tables 5 & 6). At our third evaluation, means of the resistant and susceptible internal controls were 3.2 and 5.3 (scale of 0-10), respectively, across the nursery. In 1997 (September 8), these means were 3.7 and 7.3, respectively. Means of contributor lines on September 8 ranged from 2.5-8.0, compared with 4.3-8.3 in the severe epidemic of 1997.

Cercospora/Curly Top-Resistant Populations with Resistance to Multiple Sugar Beet Diseases and Superior Agronomic Characteristics

Advanced breeding lines or Cercospora-resistant germplasms from Fargo (11), Salinas (18), East Lansing (14), and Fort Collins (11) were evaluated in Experiment 3A at the ARS leaf spot nursery at Ft. Collins (Table 5). An additional thirty-two Fort Collins advanced breeding lines or released germplasms were evaluated for Cercospora leaf spot resistance (Table 6). Breeding lines and family progeny were also tested at the BSDF Nursery in Kimberly, ID (Table 7). FC907, a multigerm, leaf spot resistant germplasm, is being increased and should be released from Fargo this coming year. This is a cross between FC701 and FC607, which was backcrossed four times to the leaf spot resistant parent (FC607). It has been shown to have excellent Cercospora leaf spot resistance in the last three years of testing.

Cercospora Leaf Spot/Curly Top Resistant (LSR/CTR) Breeding Populations Currently under Development.

1. Cercospora leaf spot and curly top resistant monogerm base population from a polycross of FC607 and FC604 with two Salinas germplasms 2859 and 2890.
   C. 2890 (sp) = 0790 *mm aa* x 1890 (Salinas); is seed from *aa* plants open pollinated by A- plants. 0790 = population-790 cycle 5 synthetic by S_1 progeny, *aa*, mm, O-type, good combining ability, adapted to California, S^f. 1890 = BC population to population 790 to get Rz equivalent, remains variable for M-:mm, Rz-:rzrz, etc.
   D. 2859 m (sp) = 1859, 1859R aa x A- (Salinas); Released in 1992 as C859. S^f, similar to 2890, but should have higher curly top resistance. Segregates and variable for M-:mm, Rz-:rzrz, A-:aa, predominant background is lines like C563.

2. Cercospora leaf spot and curly top resistant multigerm base population from a polycross of FC902 with two Salinas germplasms 278 and 4918.
   A. 278 (Iso 83) = RZM R078; R278 is Rz (segregates Rz--:rzrz) version of C46. It should be S^sS^s, MM.

B. 4918 (sp) = RZM 3918aa X A-, 142 aa plants; This is an increase of released material C918. It should be Multigerm, over 75% S^f and segregating for A-, R-, Rz-, VY, CT, Erw, & PM.

3. Cercospora leaf spot and curly top resistant multigerm, self-incompatible base population from a polycross of FC607 x [SR87, MonoHy A4, MonoHy T6, & MonoHy T7]

4. The multigerm pollinator, FC907{ = ([FC701/4 x FC607] x FC607)BC_4}, developed in the Fargo program is being increased for release.

5. Seed from FC709-2 x FC907 was sent to Larry Campbell at Fargo to cross to Sugar beet root maggot resistant germplasm to develop a population that will produce pollinators with resistance to Rhizoctonia, Cercospora, and Root maggot.

6. Two tetraploid pollinators (FC6064X and FC6074X) were crossed to a high sucrose tetraploid population in order to produce a tetraploid Cercospora resistant pollinator population with better combining ability.

Progress in 1998

1. Selections were made this summer among half-sib progeny rows of the monogerm population. Families will be selected based on leaf spot resistance, curly top resistance, and combined leaf spot and curly top resistance. They will be increased and tested in the Cercospora nursery and curly top nursery. They have been also planted in Salinas to select for the single gene source of Rhizomania resistance. Selected roots have been recombined and the resulting population(s), tested, O-type screened, released, or reselected. This population has been split and is being selected at the USDA-ARS station in Salinas, CA for resistance to rhizomania and screened for agronomic performance and resistance to other important diseases present in California. These populations will be used to provide source populations for Cercospora and Rhizomania resistance.

2. Plants (F_2) from the CTR/LSR multigerm cross (2 above) were planted in the breeding nursery last summer and *aa* females crossed to the (FC709-2 x FC907)F_2 roots selected in the Rhizoctonia nursery. This seed was bulk increased and the resulting population will be a source of curly top resistant multigerm pollinators with leaf spot and Rhizomania resistance. It is being tested this summer.

3. Plants (F_2) from the Fort Collins and Fargo joint project (3) were grown in the breeding nursery and these roots were planted in Masonville this summer and selfed, taking advantage of the 'pseudo self-fertility' that occurs in this environment. This selfed seed will be progeny tested this summer. This population will be a source of highly leaf spot resistant multigerm pollinators with curly top resistance and good combining ability for agronomic traits.

4. FC907 should be released as soon as there is sufficient seed. This Cercospora leaf spot-resistant, multigerm parent developed in Fargo (FC907), has been crossed with FC709-2, a Rhizoctonia and Cercospora resistant multigerm pollinator germplasm from Fort Collins. This population will

be a source of self-incompatible lines with excellent root rot and leaf spot resistance. This F_2 population was selected in the Rhizoctonia nursery last year and was bulk-increased in the greenhouse this winter. It was tested in both Rhizoctonia and Cercospora nurseries this summer. It has also been crossed with a high sucrose population and a population with curly top resistance. Seed from these populations will be re-selected for resistance to leaf spot, root rot, and curly top as well as agronomic performance.

5. The F_1 hybrid of FC907 x FC709-2 was crossed in the greenhouse in Fargo with root maggot resistant germplasm. The resulting population F_2 was grown out in Fargo and selected to produce plants that have combined resistance to leaf spot, root rot, and root maggot. This is a continuing joint USDA project to combine root maggot resistance with resistance to other important diseases.

6. F_1 seed has been harvested and the F_2 bulk increased in the greenhouse this winter. It will be screened and selected next summer in the field.

The seed from the above mentioned populations will be developed and advanced after testing. Development of a resistant germplasm line generally takes 7 years. A longer time may be necessary to incorporate multiple disease resistances. In an established program, a "pipeline" of lines in various stages of development and evaluation is the norm. Hence, the release of new germplasm usually occurs every 2 to 4 years.

Genetic information developed in this research will be used to execute additional cycles of pathogen inoculation, plant selection, and recombination among germplasms that we have in our leaf spot improvement program. Results of these tests will be the basis of decisions about specific germplasm, i.e., retain, discard, recombine, release, etc. Germplasms likely to be useful for variety improvement are identified and released for use by other sugar beet breeders. Breeding techniques are compared in developing these germplasm and information on the efficacy and efficiency of these techniques generated.

Table 5. Experiment 3A, 1998. Leaf Spot Evaluation of USDA-ARS Fort Collins, Salinas, East Lansing, and Fargo breeding lines

Entry No.	Seed Source		USDA-ARS Location	Disease Index[1] 08/25/98	09/03/98	09/08/98
			$LSD_{(0.05)}$	0.70	0.87	0.96
1412	931002	LSS[2]		4.0	4.2	4.5
1413	821051H2	LSR[3]		2.7	2.7	3.2
1385	97A050	FC607	Fort Collins	2.5	2.8	3.0
1389	921024	FC709-2	Fort Collins	2.8	2.7	3.0
1388	831085HO	FC708	Fort Collins	2.8	2.7	3.0
1373	96A009	EL50	East Lansing	2.7	2.8	3.2
1386	921022	FC702-7	Fort Collins	2.5	2.8	3.2
1360	98J09-00		East Lansing	2.8	2.5	3.3

Table 5. Experiment 3A, 1998. Leaf Spot Evaluation of USDA-ARS Fort Collins, Salinas, East Lansing, and Fargo breeding lines

Entry No.	Seed Source		USDA-ARS Location	Disease Index[1]		
				08/25/98	09/03/98	09/08/98
			$LSD_{(0.05)}$	0.70	0.87	0.96
1412	931002	LSS[2]		4.0	4.2	4.5
1413	821051H2	LSR[3]		2.7	2.7	3.2
1397	CR712		Salinas	3.2	2.8	3.3
1376	972026		Fargo	2.8	2.8	3.3
1379	972023		Fargo	2.8	2.8	3.3
1404	R710		Salinas	3.0	2.8	3.3
1369	96RR		East Lansing	3.0	3.0	3.3
1390	911026HO	FC715	Fort Collins	2.8	3.0	3.3
1364	WC960444	SR87	East Lansing	2.8	3.0	3.3
1382	96N0012		Fargo	2.7	3.0	3.3
1362	98J27-00		East Lansing	3.2	3.0	3.3
1395	CR 711		Salinas	3.2	3.0	3.3
1366	96HS3-01		East Lansing	3.0	2.8	3.5
1380	96N0009		Fargo	3.0	2.7	3.5
1374	AF89-212	FC607	Fargo	3.2	3.0	3.5
1387	921021	FC703-5	Fort Collins	3.2	2.8	3.5
1372	97A004	EL48	East Lansing	2.7	3.2	3.5
1400	R709-1		Salinas	2.8	2.8	3.5
1371	WC970457		East Lansing	3.2	3.0	3.5
1398	CR713		Salinas	3.3	2.8	3.5
1361	98J11-011		East Lansing	3.0	3.0	3.5
1394	97-SP22-0		Salinas	3.2	2.7	3.5
1402	R709-9		Salinas	2.7	2.8	3.5
1381	96N0011		Fargo	3.0	2.8	3.7
1406	R710-10		Salinas	2.7	3.0	3.7
1405	R710 HSO		Salinas	3.2	3.0	3.7
1392	951017	FC727	Fort Collins	3.3	3.3	3.7
1393	921025	FC728	Fort Collins	3.0	3.2	3.7
1378	972029		Fargo	3.2	3.2	3.8
1391	911031	FC717	Fort Collins	3.0	3.2	3.8
1375	972025		Fargo	3.3	3.2	3.8
1384	97N0051		Fargo	3.3	3.0	3.8
1377	972024		Fargo	3.2	3.3	3.8
1363	97J51-00		East Lansing	3.0	3.5	4.0
1408	R710-14HSO		Salinas	3.2	3.0	4.0
1399	7932CT		Salinas	3.2	2.8	4.0
1403	R709-9HSO		Salinas	3.3	3.5	4.2
1365	WC960448	SR94	East Lansing	3.2	3.3	4.2
1367	WC960452		East Lansing	3.0	3.2	4.2

Table 5. Experiment 3A, 1998. Leaf Spot Evaluation of USDA-ARS Fort Collins, Salinas, East Lansing, and Fargo breeding lines

Entry No.	Seed Source		USDA-ARS Location	Disease Index[1] 08/25/98	09/03/98	09/08/98
			$LSD_{(0.05)}$	0.70	0.87	0.96
1412	931002	LSS[2]		4.0	4.2	4.5
1413	821051H2	LSR[3]		2.7	2.7	3.2
1409	R726		Salinas	3.3	3.7	4.3
1370	WC970308		East Lansing	4.0	4.0	4.5
1410	Y769(Iso)		Salinas	3.7	4.0	4.5
1401	R709-1HSO		Salinas	4.2	4.2	4.7
1407	R710-10HSO		Salinas	3.8	4.0	4.7
1368	SR93		East Lansing	4.0	4.3	5.0
1383	97N0132		Fargo	3.8	3.8	5.0
1396	CR711HSO		Salinas	4.2	4.3	5.2
1411	5KJ0142		Salinas	5.8	6.8	7.2

[1]Disease Index is based on a scale of 0 (=healthy) to 10 (=dead).
[2]The Leafspot Susceptible Check is SP351069-0.
[3]The Leafspot Resistant Check is FC 504CMS/FC 502-2//SP6322-0

Table 6. Experiment 8A, 1998. Leaf Spot Evaluation of USDA-ARS Fort Collins.

Seed Source & Description			Disease Index[1] 08/25/98	09/03/98	09/08/98
		$LSD_{(0.05)}$	1.04	0.88	0.97
821051H2	resistant check[2]		1.67	2.17	2.83
931002	susceptible check[3]		6.00	5.67	5.83
971017	FC710 (4X)		1.33	2.17	2.50
921024	FC709-2		1.83	2.33	2.67
971013PF			1.83	2.50	2.83
86A005	SP 8540-0		2.67	2.33	3.00
96A003	892016H2	FC607 OT/Beta 2007 (2X)	2.17	2.83	3.00
78A044	FC606		1.83	2.50	3.00
971020	FC907-1	FC607/FC701 BC_4	2.00	2.17	3.00
96A002	892010H2	FC607 OT/ Hilleshög 8277	2.33	2.67	3.00
86A013	SP 85657-01		2.33	2.33	3.17
961014	FC724	FC702/LSR-CTR	2.17	2.67	3.17
961015	FC720	C718//(C718/FC708)	2.50	2.67	3.17
97A051	FC607CMS		2.00	2.67	3.33
961011HO		FC607/FC708	2.17	2.50	3.33
961011HO1		FC607/FC708CMS	2.83	2.83	3.33
86A007	SP 85576-01		2.33	2.50	3.33
971018	FC712 (4X)		2.17	2.33	3.33

Table 6. Experiment 8A, 1998. Leaf Spot Evaluation of USDA-ARS Fort Collins.

Seed Source & Description			Disease Index[1]		
			08/25/98	09/03/98	09/08/98
		$LSD_{(0.05)}$	1.04	0.88	0.97
821051H2	resistant check[2]		1.67	2.17	2.83
931002	susceptible check[3]		6.00	5.67	5.83
97A050	FC607		2.33	2.83	3.50
951016HO	FC723	EL44/FC708 mm	2.33	2.50	3.50
86A008	SP 85576-0		2.50	3.00	3.50
951016HO1	FC723CMS	EL44/FC708 CMS	2.67	3.17	3.67
981009H		907/709-2F2-Sel Rhzc	2.83	3.00	3.67
961010HO1	FC722CMS	C718/FC708 CMS	2.67	3.00	3.67
921019	FC729	FC712/A4 3 cycles of RhzcR	2.83	3.17	3.67
961010HO	FC722	C718/FC708	2.67	3.33	3.83
981007H		LSR-RHZCR	3.17	3.50	3.83
951013		Source population	3.00	3.17	3.83
86A014	SP 85657-0		3.33	3.00	4.00
971012PF			2.67	3.00	4.00
981012		LSR-CTR	3.33	3.50	4.17
971010			4.17	4.67	5.50

[1]Disease Index is based on a scale of 0 (=healthy) to 10 (=dead).
[2] The Leafspot Resistant Check is FC 504CMS/FC 502-2//SP6322-0
[3]The Leafspot Susceptible Check is SP351069-0.

Table 7. 1998 Curly Top Nursery in Kimberly Idaho.

Entry	Seed Source	Description	Disease Index[1]	
			08/27/98	09/16/98
138	**911032**	**FC718 – Susceptible Check**	**2.5**	**5.0**
139	**94A068**	**Beta G6040 – Resistant Check**	**2.5**	**3.0**
207	981012	LSR-CTR	3.3	4.0
203	951016HO1	FC723CMS EL44/FC708 CMS	2.3	4.3
202	951016HO	FC723 EL44/FC708 mm	3.0	4.3
214	971020	FC907-1 FC607/FC701 BC4	2.7	4.3
212	971017	FC710 (4X)	3.0	4.7
213	971018	FC712 (4X)	3.0	4.7
205	961011HO1	FC607/FC708CMS	2.7	5.0
200	961010HO	FC722 C718/FC708	3.7	5.0
215	961015	FC720 C718//(C718/FC708)	3.3	5.0
201	961010HO1	FC722CMS C718/FC708 CMS	3.0	5.3
204	961011HO	FC607/FC708	3.3	5.3
208	981009H	907/709-2F2-Sel Rhzc	4.0	5.3
209	961014	FC724 FC702/LSR-CTR	3.3	5.3
216	921019	FC729 FC712/A4 3 cycles of Rhizoc selection	3.7	5.7
9	981010 -16		2.0	3.0
2	981010 -5		2.0	3.0

Table 7. 1998 Curly Top Nursery in Kimberly Idaho.

Entry	Seed Source	Description	Disease Index[1] 08/27/98	09/16/98
138	**911032**	**FC718 -- Susceptible Check**	**2.5**	**5.0**
139	**94A068**	**Beta G6040 -- Resistant Check**	**2.5**	**3.0**
3	981010 -6		2.0	3.0
33	981011 -21		2.0	3.0
23	981011 -8		2.0	3.0
10	981010 -17		2.0	3.0
98	981007 -40		2.0	3.0
95	981007 -35		2.0	3.0
185	98A0 -87		2.5	3.0
44	981006 -17		2.0	3.5
47	981006 -21		2.0	3.5
62	981006 -54		2.5	3.5
73	981006 -70		2.5	3.5
45	981006 -18		2.0	3.5
115	981007 -78		2.0	3.5
152	98A0 -53		3.0	3.5
20	981011 -4		2.0	3.5
26	981011 -11		2.0	3.5
32	981011 -18		2.5	3.5
5	981010 -8		2.0	3.5
178	98A0 -80		2.5	3.5
90	981007 -20		2.0	3.5
136	981007 -135		2.5	3.5
92	981007 -29		2.0	3.5
91	981007 -24		2.5	3.5
164	98A0 -66		2.0	3.5
160	98A0 -62		2.5	3.5
155	98A0 -57		2.0	3.5
154	98A0 -55		3.0	3.5
153	98A0 -54		2.5	3.5
101	981007 -44		1.5	3.5
97	981007 -38		2.0	3.5
191	98A0 -93		2.0	3.5
94	981007 -34		2.5	3.5
114	981007 -76		2.5	3.5
194	98A0 -96		2.5	3.5
193	98A0 -95		2.5	3.5
89	981007 -19		2.0	3.5
137	981007 -139		2.0	3.5
18	981011 -1		2.0	3.5
83	981007 -7		2.5	3.5
188	98A0 -90		3.0	4.0
196	98A0 -98		3.0	4.0
192	98A0 -94		2.5	4.0
175	98A0 -77		2.5	4.0

Table 7. 1998 Curly Top Nursery in Kimberly Idaho.

Entry	Seed Source	Description	Disease Index[1] 08/27/98	09/16/98
138	**911032**	**FC718 – Susceptible Check**	**2.5**	**5.0**
139	**94A068**	**Beta G6040 – Resistant Check**	**2.5**	**3.0**
149	98A0 -50		4.0	4.0
151	98A0 -52		3.5	4.0
80	981007 -2		3.0	4.0
79	981006 -110		3.0	4.0
41	981006 -10		2.0	4.0
179	98A0 -81		3.0	4.0
180	98A0 -82		2.5	4.0
35	981011 -45		2.5	4.0
27	981011 -12		2.5	4.0
11	981010 -18		3.5	4.0
15	981010 -23		2.5	4.0
4	981010 -7		2.5	4.0
128	981007 -106		2.5	4.0
113	981007 -65		2.0	4.0
131	981007 -116		2.5	4.0
129	981007 -112		3.0	4.0
118	981007 -83		3.0	4.0
135	981007 -125		3.0	4.0
88	981007 -18		3.0	4.0
93	981007 -31		2.0	4.0
108	981007 -55		3.0	4.0
109	981007 -56		2.5	4.0
110	981007 -58		3.0	4.0
119	981007 -90		3.0	4.0
74	981006 -71		3.0	4.0
87	981007 -15		2.5	4.0
68	981006 -60		2.5	4.0
43	981006 -15		2.0	4.0
67	981006 -59		2.5	4.0
181	98A0 -83		2.5	4.0
182	98A0 -84		3.0	4.0
183	98A0 -85		3.0	4.0
184	98A0 -86		3.0	4.0
64	981006 -56		3.0	4.0
186	98A0 -88		2.5	4.0
28	981011 -13		3.0	4.0
6	981010 -9		2.5	4.0
34	981011 -29		2.0	4.0
31	981011 -17		2.5	4.0
29	981011 -15		3.5	4.0
22	981011 -7		3.0	4.0
21	981011 -5		2.0	4.0
42	981006 -12		3.0	4.5

Table 7. 1998 Curly Top Nursery in Kimberly Idaho.

Entry	Seed Source	Description	Disease Index[1] 08/27/98	09/16/98
138	**911032**	**FC718 – Susceptible Check**	**2.5**	**5.0**
139	**94A068**	**Beta G6040 – Resistant Check**	**2.5**	**3.0**
69	981006 -61		3.0	4.5
53	981006 -32		3.5	4.5
84	981007 -11		2.5	4.5
50	981006 -26		3.0	4.5
82	981007 -6		3.0	4.5
81	981007 -5		2.5	4.5
187	98A0 -89		3.5	4.5
132	981007 -119		3.0	4.5
133	981007 -123		3.5	4.5
117	981007 -82		3.0	4.5
116	981007 -80		3.0	4.5
170	98A0 -72		3.0	4.5
112	981007 -60		2.5	4.5
134	981007 -124		3.0	4.5
75	981006 -72		3.0	4.5
99	981007 -41		3.0	4.5
49	981006 -25		3.0	4.5
36	981006 -2		2.5	4.5
56	981006 -36		3.5	4.5
85	981007 -13		3.5	4.5
106	981007 -52		3.0	4.5
51	981006 -27		3.5	4.5
7	981010 -11		3.5	4.5
12	981010 -19		4.0	4.5
1	981010 -4		3.0	4.5
197	98A0 -99		3.5	4.5
65	981006 -57		3.5	4.5
189	98A0 -91		3.5	4.5
71	981006 -65		3.0	4.5
102	981007 -45		2.5	4.5
104	981007 -50		3.5	4.5
96	981007 -36		2.0	4.5
48	981006 -23		3.0	4.5
63	981006 -55		3.5	4.5
40	981006 -7		3.0	4.5
122	981007 -93		3.5	4.5
146	98A0 -46		3.5	4.5
167	98A0 -69		3.0	4.5
177	98A0 -79		3.0	4.5
173	98A0 -75		3.0	4.5
141	98A0 -41		3.0	4.5
150	98A0 -51		2.5	4.5
30	981011 -16		2.5	4.5

Table 7. 1998 Curly Top Nursery in Kimberly Idaho.

Entry	Seed Source	Description	Disease Index[1] 08/27/98	09/16/98
138	**911032**	**FC718 – Susceptible Check**	**2.5**	**5.0**
139	**94A068**	**Beta G6040 – Resistant Check**	**2.5**	**3.0**
165	98A0 -67		2.5	4.5
24	981011 -9		3.0	4.5
19	981011 -3		3.0	4.5
25	981011 -10		2.5	4.5
176	98A0 -78		2.5	4.5
174	98A0 -76		3.0	4.5
156	98A0 -58		3.0	4.5
130	981007 -114		3.0	5.0
100	981007 -42		2.5	5.0
105	981007 -51		3.0	5.0
111	981007 -59		2.5	5.0
142	98A0 -42		3.5	5.0
14	981010 -21		3.0	5.0
148	98A0 -49		4.0	5.0
8	981010 -15		4.0	5.0
107	981007 -53		2.5	5.0
70	981006 -62		2.5	5.0
55	981006 -34		3.0	5.0
54	981006 -33		3.0	5.0
78	981006 -87		3.0	5.0
72	981006 -68		3.0	5.0
120	981007 -91		3.0	5.0
144	98A0 -44		4.0	5.0
158	98A0 -60		3.0	5.0
13	981010 -20		3.5	5.0
52	981006 -31		3.5	5.0
161	98A0 -63		3.5	5.0
162	98A0 -64		3.5	5.0
163	98A0 -65		4.0	5.0
57	981006 -37		3.5	5.0
46	981006 -19		2.5	5.0
166	98A0 -68		4.0	5.0
58	981006 -38		3.5	5.0
168	98A0 -70		3.0	5.0
169	98A0 -71		3.5	5.0
103	981007 -48		3.5	5.0
172	98A0 -74		4.0	5.0
195	98A0 -97		3.5	5.0
159	98A0 -61		3.5	5.5
86	981007 -14		3.5	5.5
147	98A0 -47		4.0	5.5
145	98A0 -45		4.0	5.5
143	98A0 -43		4.0	5.5

Table 7. 1998 Curly Top Nursery in Kimberly Idaho.

Entry	Seed Source	Description	Disease Index[1] 08/27/98	09/16/98
138	**911032**	**FC718 – Susceptible Check**	**2.5**	**5.0**
139	**94A068**	**Beta G6040 – Resistant Check**	**2.5**	**3.0**
123	981007 -94		4.5	5.5
38	981006 -4		4.0	5.5
171	98A0 -73		4.0	5.5
59	981006 -41		4.5	5.5
37	981006 -3		4.0	5.5
76	981006 -75		3.5	5.5
60	981006 -43		4.5	5.5
121	981007 -92		3.0	5.5
39	981006 -6		4.0	5.5
61	981006 -48		4.0	5.5
17	981010 -30		3.5	6.0
124	981007 -95		4.5	6.0
127	981007 -105		3.5	6.0
157	98A0 -59		4.5	6.0
126	981007 -97		4.5	6.5
140	98A0 -40		4.5	6.5
16	981010 -28		4.5	6.5
77	981006 -76		4.5	6.5
66	981006 -58		5.0	6.5
198	98A -100		5.5	6.5
125	981007 -96		5.5	7.0

[1]Disease Index is based on a scale of 1 (=healthy) to 9 (=dead).

PRE-BREEDING: THE INTROGRESSION OF NEW SOURCES OF CERCOSPORA LEAF SPOT RESISTANCE FROM *BETA VULGARIS* SPP. *MARITIMA* AND OTHER EXOTIC SOURCES INTO SUGAR BEET-TYPE POPULATIONS. (BSDF Project 443)

L. Panella

A major emphasis of the research mission of the USDA-ARS plant scientists is the collection, documentation, characterization, evaluation, regeneration (maintenance), distribution, and utilization of plant germplasm, especially Plant Introduction (PI) accessions in the USDA-ARS National Plant Germplasm System (NPGS). The Sugar Beet Research Unit at Fort Collins is coordinating the national program for *Beta* germplasm evaluation. In addition to the evaluation for Rhizoctonia and Cercospora resistance, it is crucial that the ARS scientist be involved in the long rang, high risk research problems involved in sugar beet 'germplasm enhancement' or 'pre-breeding'. This is an important component in the overall sugar beet improvement effort of the Fort Collins Sugar Beet Research Unit.

Justification for Research: Cercospora leaf spot (caused by the fungus *Cercospora beticola* Sacc.) is one of the most widespread diseases of sugar beet and is a serious problem in many sugar beet production areas throughout the U.S. The disease damages the leaves, which, consequently, reduces root yield, percent sucrose of roots, and purity of the extracted juice. Cercospora leaf spot currently is controlled by combining spraying with commercial fungicides and the use of disease tolerant germplasm. The development of Cercospora leaf spot resistant sugar beet lines and hybrids with greater levels of host-plant resistance offers a more sustainable solution to this disease problem.

If the level of resistance available in some Cercospora-resistant experimental breeding lines were present in commercial hybrids (**along with good sugar and seed yield**), the need for fungicides could be greatly reduced. That continued improvement in genetic resistance to this serious pathogen is still needed is evident by the occurrence of *Cercospora* strains that are tolerant to our most potent fungicides. Additionally, some fungicides may be removed from the market because of their perceived or real threat to the environment.

Finally, the genepool for resistance to Cercospora leaf spot is extremely narrow. Many of the resistant lines are highly inbred, therefore, closely related to one another, and stem from germplasm coming out of Italy in the early 1900s. In the germplasm developed at Fort Collins, continued inbreeding has increased the level of disease resistance, but at the cost of plant vigor. Over the long term, a secure, sustainable response to this disease requires commercial quality hybrids with good host-plant resistance.

Objectives:

1. The formation of long range breeding populations through the introgression of Cercospora resistant germplasm from "exotic" sources (*Beta vulgaris* spp. *maritima*, fodder beet, foreign sugar beet landraces from the PI collection, etc.).

2. The development of germplasm populations from these long range populations that are of sufficient agronomic quality to be of use to commercial breeders. They will be a source of

leaf spot resistance with differing genetic backgrounds.

3. The development of techniques (both traditional and molecular) to more efficiently introgress the exotic germplasm into sugar beet breeding populations.

Research Progress 1998:

Crosses have been made or are being attempted in the greenhouse on the list of accession below (Table 8), all of which have been identified as having Cercospora resistance. F_1 seed of three crosses (96A011, 96A015, and 96A016 as donor parents) is being bulk increased in the greenhouse (Table 9). All show some biennial plants in our environment and were crossed to genetic male sterile (*aa*) sugar beets. These crosses should be completed by the beginning of 1999. At that point we will consider re-crossing some of those from which we obtained insufficient seed.

Seed from the first three crosses is maturing and will be harvested early summer; it will be random mated this coming season. The annuals will be handled in a similar fashion once they have been crossed. All will be cycled through at least three cycles of random mating.

Table 8. Exotic Cercospora-leaf-spot-resistant (LSR) donor parents identified for this project

Accession Number	Donor Designation	Name or Origin	% Bolting without induction 1996 Fort Collins
96A010	PI 535826	Giant Poly	20%
96A011	PI 535833	Saturn	0%
96A014	PI 540593	WB 847	0%
96A015	PI 540596	WB 850	70%
96A017	PI 540605	WB 859	25%
96A012	PI 535843	PN MONO 1	100%
96A013	PI 540575	WB 829	100%
96A016	PI 540599	WB 853	50%
94A079	#32375 (*B. v.* ssp. *maritima*)	Greece	annual
94A080	#36538 (*B. v.* ssp. *maritima*)	Greece	annual
94A081	#45511 (*B. v.* ssp. *maritima*)	Greece	annual
94A082	#45516 (*B. v.* ssp. *maritima*)	Greece	annual
94A083	#48810 (*B. v.* ssp. *maritima*)	Tunisia	annual
94A084	#48819 (*B. v.* ssp. *maritima*)	Tunisia	annual
94A085	#51430 (*B. v.* ssp. *maritima*)	Greece	annual

Table 9. Crosses between commercial sugar beet type and exotic Cercospora-leaf-spot-resistant (LSR) donor parents

Seed No.	F_1 Crosses Attempted
971021	Cross of Sucrose MM (961005aa) plants with PIs that were evaluating as having LSR (PI535826 - biennial)
971022	Cross of Sucrose MM (961005aa) plants with PIs that were evaluating as having LSR (PI535833 - biennial)
971023	Cross of Sucrose MM (961005aa) plants with PIs that were evaluating as having LSR (PI540593 - biennial)
971024	Cross of Sucrose MM (961005aa) plants with PIs that were evaluating as having LSR (PI540596 - biennial)
971025	Cross of Sucrose MM (961005aa) plants with PIs that were evaluating as having LSR (PI540605 - biennial)
971026	Cross of Sucrose MM (961005aa) plants with PIs that were evaluating as having LSR (PI535843 - annual)
971027	Cross of Sucrose MM (961005aa) plants with PIs that were evaluating as having LSR (PI540575 - annual)
971028	Cross of Sucrose MM (961005aa) plants with PIs that were evaluating as having LSR (PI540599 - annual)
971029	Cross of Sucrose MM (961005aa) plants with PIs that were evaluating as having LSR (#32375 94A079 - annual)
971030	Cross of Sucrose MM (961005aa) plants with PIs that were evaluating as having LSR (#36568 94A080 - annual)
981001	Cross with Sucrose MM (961005aa) - LSR population, B v sp maritima from BAZ Genebank (#45511 from the Peloppennese)
981002	Cross with Sucrose MM (961005aa) - LSR population, B v sp maritima from BAZ Genebank (#45516 from the Peloppennese)
981003	Cross with Sucrose MM (961005aa) - LSR population, B v sp maritima from BAZ Genebank (#48810 from the Peloppennese)
981004	Cross with Sucrose MM (961005aa) - LSR population, B v sp maritima from BAZ Genebank (#48819 from the Peloppennese)
981005	Cross with Sucrose MM (961005aa) - LSR population, B v sp maritima from BAZ Genebank (#51430 from the Peloppennese)
Seed No.	**F_2 Seed Produced**
981031	Increase of 971021H2 (Sucrose MM (961005aa) x LSR PI535826) biennial maritima LSR source introgression
981032	Increase of 971024H2 (Sucrose MM (961005aa) x LSR PI540596) biennial maritima LSR source introgression
981033	Increase of 971028H2 (Sucrose MM (961005aa) x LSR PI540599) annual maritima LSR source introgression

Development of a resistant germplasm line generally takes seven years. A longer time will be necessary to incorporate disease resistance from more exotic sources. Because this is a new program it will take time for the first germplasm to make it through the process. Once that happens, there will be a "pipeline" of germplasm in various stages of development and the release of new germplasm will occur every two to four years. The incorporation of exotic sources into agronomically acceptable germplasm is a long term proposition - results will not appear overnight. This is the type of long-term, high risk germplasm research that ARS is well-suited to perform.

Materials and Methods: Artificial inoculation with *Cercospora beticola* and leaf spot scoring will be used to identify the resistant germplasm sources and make selections in the developing populations. The exotic materials will be crossed into sugar beet populations that have been selected for agronomic quality (recoverable sucrose yield). These are currently under development using germplasm received from commercial breeding programs, public sources (e.g., L19), and some high sucrose germplasm from Poland. These sugar beet populations will be self-fertile (S^f) and segregating for nuclear male sterility (*A-:aa*). Populations will be handled in the following manner: 1) Following the initial cross, a population will be random mated (using *aa* females because of the self-fertility) for three to four generations to break up linkage groups and remove annual plants. 2) Sugar beet-type mother roots will be selected, selfed, and progeny tested for agronomic performance and disease resistance. 3) Selected roots will be recombined (and backcrossed if desirable) and re-selected until they ready for release. Molecular markers (RFLPs, RAPDs, SSRs, AFLPs, etc.) will be used to expedite the backcrossing program and to follow the change in allele frequencies in the selected populations. Advanced populations will be released to the sugar beet seed industry.

Summary of Literature: Cercospora leaf spot has been an intermittent problem in sugar beet growing areas of the United States where the summers can be hot and humid (Red River Valley, Michigan, Ohio, and, less often, Great Plains growing areas and California). It has been estimated that a severe epidemic can cause up to a 42% loss of gross sugar (Smith and Martin, 1978; Smith and Ruppel, 1973), or up to a 43% relative dollar loss (Shane and Teng, 1992).

Resistance to Cercospora leaf spot has long been a goal of the USDA-ARS sugar beet research program at Fort Collins and researchers there developed the techniques necessary to manage the screening nurseries in such a way as to promote the development of the disease (Ruppel and Gaskill, 1971). A careful crop rotation (sugar beet-barley-barley-barley-sugar beet) and the arid climate and low relative humidity have allowed this to be done in such a manner that there are rarely high enough levels of any other disease present in the leaf spot nursery to confound the results.

There are an estimated 4 or 5 genes responsible for *Cercospora* resistance (Smith and Gaskill, 1970) and broad-sense heritability estimates ranged from 12 to 71% (Bilgen et al., 1969). Narrow-sense heritability estimates of about 24% compared well with realized heritability values, and 44 to 62% of the variation was due environment in this test (Smith and Ruppel, 1974). The large environmental variation has made it difficult to make progress in developing *Cercospora* resistance through mass selection. Incorporation of high levels of leaf spot resistance into varieties with superior agronomic performance also is difficult (Smith and Campbell, 1996) and, therefore, commercial resistant varieties require some fungicide application to provide adequate levels of protection against Cercospora (Miller et al., 1994).

A major problem in the development of *Cercospora*-resistant sugar beet is the loss of vigor due to the continual inbreeding. Coons (1955) noted this and it has been a concern ever since (McFarlane, 1971). The use of hybrid varieties has ameliorated this problem to some extent, but seed production on the highly inbred O-type males and CMS females still is a problem. This is seen in germplasm from both the FC 500 and FC 600 series developed at Fort Collins.

The USDA-ARS National Plant Germplasm System *Beta* collection has over 2,000 Plant Introduction (PI) accessions. The germplasm used most often in sugar beet breeding is from *Beta vulgaris* spp. *vulgaris*, which includes all of the biennial sugar beet types, or from *Beta vulgaris* spp. *maritima*, which contains the closely related wild sea beet and has both annual and biennial types. Germplasm with a biennial flowering habit is easier both to introgress and screen. *Beta vulgaris* spp. *maritima* has, nonetheless, been used as a source of resistant germplasm. Much of the *Cercospora*-resistant germplasm in use today came out of Munerati's program in Italy, in which *B. vulgaris* spp. *maritima* was the source of resistance genes (Lewellen, 1992). There have been very few new efforts to locate and incorporate other sources of resistance to *Cercospora* into this narrow germplasm base.

There is an urgent need to continue to create in our *Cercospora*-resistant germplasm a broader genetic base than we have today. As commercial hybrid parents become more inbred, the germplasm base from which these inbred parents are developed must have the diversity necessary to provide for maximum gain through heterosis. Munerati's success, and the research of others, has shown that it can be done if we have the persistence to do it (Bilgen et al., 1969; Doney, 1993; Lewellen, 1995).

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Transgenic Approaches to Modify Sucrose Distribution in Sugarbeet

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The proton-coupled sucrose transport protein mediates the key step in the long-distance transport of newly synthesized sucrose from the leaf to the taproot for storage. We have cDNA clones that code for this sucrose transporter. This transport protein is an excellent candidate for genetic engineering because it is capable of loading plant cells with molar concentrations of sucrose. Thus, directed expression of the gene for the sucrose transporter in the taproot could be used to enhance sucrose accumulation by increasing the uptake capacity of the storage cells. Moreover, we have discovered that a single amino acid substitution generates a transport protein that is 10- to 15-fold more active than the wild-type transporter. The long-term goal of this proposal is to increase sucrose storage in the taproot by using transgenic methods to express the "hyperactive" sucrose transporter in the storage cells of the taproot. The focus of the first year's research was to confirm our initial observation that a single amino acid change in the transport protein increased transport activity and secondly, to lay the foundation for cloning unique promoters that direct gene expression in the root tissues of plants.

Progress to Date

Since starting this project, we have made significant progress in describing the transport activity of the hyperactive form of the sucrose transporter we engineered with recombinant DNA technology, and we have started our analysis of transposon-tagged plants that will be used to clone tissue specific promoters. We showed that hyperactive transport activity is the result of faster flux through the transport protein versus increased abundance of the protein per cell. This was a key finding because it shows that the substituted amino acid plays an important role in the transport mechanism, which represents an important contribution our understanding of how this transport protein works. In addition, this was a key finding with regard to this project because it shows we do not have to over-express the sucrose transporter in the taproot to achieve significantly increased transport capacity. The results of our work with the hyperactive transporter were published in the Proceedings of the National Academy of Sciences.

The second major project this year was completing a thorough analysis of the expression pattern of transposon-tagged genes whose expression is limited to root tissue. We have showed that these genes are expressed in the root throughout the plant life cycle. We have also obtained short runs of genomic sequence that is adjacent to the inserted transposon. These genomic sequences will allow us to begin to clone the genes that have been tagged by the transposon. Since expression of these genes is limited to the root tissue, their promoters can be used to target hyperactive sucrose transporter expression in the taproot of transformed sugarbeet.

Project Publications 1998:

Lu J. M.-Y. and DR Bush 1998. His-65 in the proton-sucrose symporter is an essential amino acid whose modification with site-directed mutagenesis increases transport activity. *Proc. Natl. Acad. Sci. USA* **95**:9025-9030

SUGAR BEET RESEARCH

1998 REPORT

Section C

U. S. D. A., A. R. S., Western Regional Plant Introduction Station
Pullman, Washington

Dr. Alan Hodgdon, *Beta* Curator

This research was supported in part by funds provided through the Beet Sugar Development Foundation (Project 290)

CONTENTS

Status report on the *Beta* germplasm collection activities at the USDA, ARS, Western Regional Plant Introduction Station To the Beet Sugar Development Foundation Curator: Dr. Alan Hodgdon, 1999

W-6 has established an excellent working relationship with the IDBB in Europe for exchanging and increasing U. S. *Beta* germplasm. Approximately 200 PI accessions are being included in the developing IDBB *Beta* core collection. We received 47 wild beet accessions from Europe, and these have been introduced into the National Plant Germplasm System. In the 1998 crop year 80 PI's were increased in Europe (Table 1). Of these, 16 accessions are on our priority seed increase list. We have also had great support from *Beta* seed companies in the United States through the BSDF. In the 1998-99 season, 16 beet accessions will be increased by U.S. companies. This help is greatly appreciated.

There are now down to 470 *Beta* accessions on the increase priority list. This is down from 537 in 1997. The list will decrease by about 50 when this year's seed totals are known. There are 20 accessions in our inventory that we have not been able to germinate. Sixteen of these are probably lost from the collection.

In 1998 we purchased and installed a new walk-in growth chamber for vernalizing seedlings. This is now in use and has improved our facilities greatly. Our farm manager has constructed an excellent new seed thresher which will be used mainly for the *Beta* program. The principle problems with our current increase program are lack of greenhouse space and poor overwintering of our field plots. We may have to increase all biennial *Beta* in the greenhouses using artificial vernalization, and we are trying to get more greenhouse space.

In 1998 we viability tested 54 samples from the 1996 harvest. Of these accessions, two had less than 50% viability. Nineteen of these accessions were more than 40% dormant. Samples from 45 accessions from the 1997 harvest are now being germ tested. Also at NSSL, 19 accessions of W-6 increases from 1993, 1994, and 1995 were tested. One of these samples had 30% viability and the remaining were in the 80-90% range.

We continue to backup seed at NSSL. At W-6 we have a new -20°C freezer for seed backup. In this program we have frozen 1,130 original *Beta* seed samples with each sample containing at least 200 seed. We have frozen 706 PI regeneration samples of 400 seed each per accession. These sample were carefully chosen for viability and to represent the original seed source. Four hundred seed should be sufficient for two regeneration cycles.

In the interest of further research and at the request of the Sugarbeet Crop Germplasm Committee we derived a core collection for the U. S. *Beta* germplasm collection. The *Beta* core collection was derived from *Beta vulgaris* ssp. *vulgaris*, and *Beta vulgaris* ssp. *maritima*. In the development of these cores two different sets of selection criteria were used depending upon the taxa.

Beta vulgaris ssp. *maritima*

1. Initially we were going to select by ecogeographical region (Mediterranean, Norther European, and Transition Zone (France)), but actually randomly selected 10% from each country, or at least one accession from each country where there were less than 10 accessions.

Beta vulgaris ssp. *vulgaris*

1. Breakdown by beet type or use type (Sugar Beet, Leaf Beet, Fodder Beet, Table Beet)

2. Similar to the *B. vulgaris* ssp. *maritima*, we were going to select by ecogeographical region (Mediterranean, Norther European, and Transition Zone (France)), but actually randomly selected 10% from each country, or at least one accession from each country where there were less than 10 accessions.

We have yet to derive a scheme to weight the US gene pool since this group is heavily represented in the sugar beets. Members of the Sugar Beet Crop Germplasm Committee are addressing this point now.

Table 1. *Beta* seed increase activity at W-6 in the years 1995- 1998.

Location	Year	# Started	No Germination	# Harvested	Carryover
W-6	1995	94	9	27	
W-6	1996	62	5	66	
W-6	1997	92	5	59	
Novartis	1997	16		16	
W-6	1998	83	7	77	74
Europe	1998	80			80
U.S.	1998	16			16
Totals		443	23	245	170

SUGARBEET RESEARCH

1998 Report

SECTION D

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Cooperation:

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Sugarbeet Research and Education Board of MN and ND
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CONTENTS

PUBLICATIONS

Abstract of papers Presented or Published

Campbell, L.G., A.W. Anderson, R. Dregseth, and L.J. Smith. 1998. Association between sugarbeet root yield and sugarbeet root maggot (Diptera: Otitidae) damage. Journal of Economic Entomology, 91:2: 522-527.

Sugarbeet root maggot, *Tetanops myopaeformis* von Röder, is a major insect pest of sugarbeet throughout much of North America. Root maggot damage is routinely rated on a 0 (no damage) to 5 (severe damage) scale. Forty-two trials were utilized to examine the relationship between visual damage and root yield. The mean damage rating in the absence of insecticides was 3.3, compared to 1.7 for the highest yielding treatment in each trial. Mean root yield of the highest yielding treatment in each trial was 48.8 per hectare, compared to a mean of 29.0 Mg ha^{-1} per hectare, when no insecticides were applied. Regression analyses within individual trials indicated that the yield loss associated with each increment of the damage rating scale fluctuated widely, ranging from near zero to 15.7 Mg ha^{-1}. The percent yield reduction in the absence of insecticides ranged from 9.8% to 83.6% when compared to the treatment providing the most effective control in each test. These results are useful in estimating losses, developing recommendations, and providing a standard of comparison for alternative control strategies.

Campbell, L.G., G.A. Smith, J.D. Eide, and L.J. Smith. 1999. Sugarbeet root maggot control with *Metarhizium anisopliae.* 1998 Sugarbeet Research and Extension Reports, Cooperative Extension Service, North Dakota State University, 29: 222-226.

Only a few insecticides are available for controlling the sugarbeet root maggot (*Tetanops myopaeformis*). These could become less effective because of the development of resistant root maggot strains or become unavailable because of environmental concerns. An effective biocontrol agent would provide an alternative and, perhaps, more consistent control method. Laboratory results and a 1995 field trial prompted further testing of the entomopathogenic fungus *Metarhizium anisopliae* (Metschn.). *Metarhizium* inoculum was prepared by culturing the fungus on heat-killed barley. The inoculated barley was spread evenly over field plots in the fall proceeding the sugarbeet crop, in the spring prior to planting, or both in the fall and spring. Root yields ranged from 49.5 Mg ha^{-1} when no insecticide was applied to 59.2 Mg ha^{-1} when Lorsban (chlorpyrifos) was used to control maggots. The fall, spring, and fall plus spring applications of *Metarhizium* yielded 51.5, 50.9, and 58.9 Mg ha^{-1}, respectively, at Crookston in 1996. The 1997 trials included the same three *Metarhizium* treatments with an additional application of *Metarhizium* in the spring

of 1996 (prior to planting barley). Root yields for the *Metarhizium* treatments ranged from 51.4 to 57.5 Mg ha^{-1}, compared to 57.6 Mg ha^{-1} when Lorsban was applied and 48.7 Mg ha^{-1} in the absence of maggot control in 1997. Yield differences between treatments were not significant in 1998 because of reduced root maggot pressure, but appeared to follow the pattern observed in the 1996 and 1997 trials. Results, to date, have been encouraging; however, additional information on application rates and timing, formulations, and the effectiveness of *Metarhizium* in more environments will be required before commercialization is feasible.

Campbell, L.G., and C. StaelVonHolstein. 1999. Storage Respiration of Roundup-ready sugarbeet hybrids. 1998 Sugarbeet Research and Extension Reports, Cooperative Extension Service, North Dakota State University 29: 299-300.

The feasibility of using broad spectrum herbicides to control weeds in sugarbeets has been demonstrated and will most likely become a commercial reality very soon. Transgenic sugarbeets with resistance to some of these herbicides promise to simplify weed control while having few negative effects. Understanding the impact, if any, of introduced genes on traits not related to herbicide response is important to producers, processors, and regulators and for public acceptance of food derived from transgenic crops. The ability to retain sugar during storage is important to sugarbeet processors. Respiration that occurs while the beets are awaiting processing is responsible for 50-70% of the sugar loss that occurs during storage. The objective of this study was to determine if the alien gene that provides Roundup resistance affects respiration during storage. Respiration rate was determined by measuring the carbon dioxide production of sugarbeets stored for 30 days at 40° F. A lack of significant differences between the non-transgenic hybrid and its transgenic counterpart when both received conventional herbicides indicates the gene conditioning resistance to Roundup is neutral in its effects upon respiration of sugarbeets. Near equality of conventional herbicides and Roundup treatments when applied to the transgenic beets indicated that the application of Roundup had no effect on storage respiration.

Campbell, L.G., G.A. Smith, H.A. Lamey, and A.W. Cattanach. 1998. Cercospora beticola tolerant to triphenyltin hydroxide and resistant to thiophanate methyl in North Dakota and Minnesota. Journal of Sugar Beet Research, 35:29-41.

Triphenyltin hydroxide (TPTH) has been used extensively for control of Cercospora (*Cercospora beticola*)leaf spot of sugarbeet (*Beta vulgaris*) in Minnesota and North Dakota following the development of benzimidazole resistant strains in the early 1980s. The discovery of tolerance to TPTH in 1994 prompted extensive sampling throughout the region in 1995 and 1996. In 1995, 60% of the leaf spots in the southern most district were tolerant to 0.2ppm TPTH and 42% tolerant to 1ppm. By 1996 these frequencies had increased to 83 and 60%, respectively. More alarming than this increase in the southern district was the rapid increase in the occurrence of

tolerance further north where the disease is generally less severe and fungicide use is less. In four of the seven factory districts the frequency of leaf spots tolerant to 0.2ppm exceeded 35% and the frequency tolerant to 1ppm was greater than 15%, in 1996. Resistance to thiophanate-methyl, a benzimidazole-type fungicide, persisted in local populations even though TPTH has been the predominant fungicide for control of Cercospora leaf spot for about 15 years.

Weiland, J.J., and G.A. Smith. 1999. Survey for the prevalence and distribution of *Cercospora beticola* tolerant to TPTH and resistant to Topsin M in 1998. 1998 Sugarbeet Research and Extension Reports, Cooperative Extension Service, North Dakota State University, 29:289-291.

Triphenyltin hydroxide (TPTH) has been used extensively in the Northern Great Plains in recent years for the control of Cercospora leaf spot on sugarbeet. Although mancozeb and, to a lesser extent, the benzimidazole fungicides often are implemented in conjunction with TPTH for optimum leaf spot control, TPTH continues to be the most widely used compound for control of the disease. Testing in our USDA-ARS Fargo laboratory of Cercospora that was isolated from leaf spot in the sugarbeet fields in North Dakota and Minnesota for the tolerance or resistance to fungicides first revealed tolerance to TPTH in 1994. The testing program has continued to the present and includes, for the first time, extensive surveying for tolerance to mancozeb. As in previous years, fields in the southern Minnesota growing region and in all factory districts from Wahpeton to Drayton in the Red River Valley were surveyed. Samples were tested for resistance to thiophanate methyl (TM; a benzimidazole fungicide) and for tolerance to TPTH and mancozeb at two different exposure levels.

CHARACTERIZATION OF GENE AND GENE PRODUCTS INVOLVED IN *CERCOSPORA* RESISTANCE IN SUGARBEET

Project 601

G.A. Smith, J.J. Weiland and J. D. Eide

Cercospora leaf spot continues to be one of the most serious diseases affecting sugarbeet. The disease, caused by the fungal pathogen *Cercospora beticola*, costs the sugarbeet industry millions in losses annually. Concerns have been raised about the rapid development of *Cercospora* strains resistant or tolerant to currently used fungicides. This underscores the need for continued research and development of new sources of *Cercospora* resistance in sugarbeet. We have obtained N-terminal sequence of a previously-uncharacterized glucanase from sugarbeet and are studying the role of sugarbeet hydrolases, glucanases, and other enzymes involved in *Cercospora* resistance. Regulatory studies on these proteins coupled with new selection techniques would enhance and accelerate the development of new *Cercospora* resistant sugarbeets. In addition, hyper-expression of these hydrolases in transgenics may provide increased leaf spot resistance.

The glucanase gene and gene products involved in *Cercospora* resistance are being examined. Previously a 26 kD glucanase was purified by chromatography and electrophoresis. The glucanase protein was transbloted to PVDF membrane for amino acid sequencing. The N-terminal amino acid sequence is as follows: H2N- Thr Thr Phe Thr Val Val Asn Asn Cys Gln. A search of Genbank suggested that this is a new antifungal protein. Similarities were found between this sequence and that of the antifungal peptides avematin and osmotin-like protein. We have used this sequence to construct PCR primers for the detection of antifungal genes in sugarbeet. The primers 26KDfwd1 (5'TCTAGAATTCACIGTIGTIAACAACTGCCA3') and 26kDrev1 (5' CCTAGGATCCTTTTTTTTTTT 3') and thirteen new arbitrary primers were obtained and are being tested. These primers were used in the PCR to amplify a 800 bp and 550 bp fragment using DNA from the leaf spot resistant germplasm accession 891021H2. These fragments were cloned and sequenced. These sequences will be useful for mapping of sugarbeet antifungal genes, some of which already may contribute to *Cercospora* resistance in resistant varieties.

RNA has been isolated from leaf spot resistant and leaf spot susceptible material with or without Cercospora infection. This RNA was used for Reverse Transcriptase-PCR(polymerase chain reaction). The following primers were used for the reverse transcriptase process, H-T_{11}A, H-T_{11}G, H-T_{11}C and 26kDrev1. This RNA will also be useful for the study of transcriptional regulation of this gene and for construction of a cDNA library. As other pathogenesis related proteins are detected they will be cloned from the same cDNA library.

USING SUGARBEET CLONES TO PRODUCE SYNTHETIC LINES WITH RESISTANCE TO RHIZOCTONIA ROOT ROT

Project 610

J.J. Weiland and G.A. Smith

Methods for the evaluation of sugarbeet for resistance to root rot caused by Rhizoctonia solani AG2-2 presently involve the generation of disease in replicated field plots. The development of a resistance screening method that could be performed in the growth chamber or greenhouse would enable researchers to evaluate candidate breeding lines for levels of resistance before use in test hybrids. In recent years, the ARS lab in Fargo has refined a technique for the inoculation and rating of young roots with *R. solani* AG2-2. A protocol is presented that permits roots of test germplasm to be evaluated at 8 weeks post-seeding. Ranking of test germplasm according to levels of disease was similar to that observed for the performance of the accessions in the root rot disease nursery at Fort Collins, CO.

This report summarizes the results of multiple trials involving germplasm accessions FC709-2 (highly resistant), FC718 (resistant), FC907 (moderately susceptible), FC403 (highly susceptible) and the hybrid, Maribo 'Ultramono' (highly susceptible). Release FC709-2 has exhibited extreme resistance to root rot over several years of testing in the Rhizoctonia nursery at Fort Collins, CO. Inoculum used in the study was *R. solani* AG2-2, which is the same isolate used in inoculation of the field nursery.

The techniques for inoculation and plant rating are as follows. Briefly, one or two sugarbeet plants are grown in 6" pots to the 5 week-old stage in a greenhouse that is maintained at an average temperature of 25°C and alternating between a 16 hr day period and an 8 hour dark period. Since 50 roots are inoculated per trial, the rearing of at least 60 plants is recommended. Two weeks prior to plant inoculation, *R. solani* AG2-2 is plated onto potato dextrose agar and incubated at 22°C in the dark. One week prior to inoculation, sterile barley grain is sprinkled onto the plated *R. solani* culture and the plates are sealed with Parafilm and returned to the incubator. The barley grains become infested with the fungus within one week. For the inoculation, two infested barley grains are place next to the root surface of a 5 week-old sugarbeet plant at ~2 cm below the surface of the soil. The soil is replaced over the grain inoculum and the plants are watered immediately after all of the plants have been inoculated.

One week after inoculation, plants of a highly susceptible check accession or variety are examined at 3-day intervals in order to monitor disease progress. When greater than 50% of the roots of this accession exhibit severe root rot (>90% of root surface exhibiting rot), all of the roots in the experiment are dug up and rated for root rot severity. This typically occurs at about 14 days post-inoculation. A 0 to 4 scale is used for evaluating root rot severity, where a plant exhibiting no disease is considered a 0 reaction, a root lesion effecting 10% or less of the root surface is a 1 reaction, a root lesion covering 11 – 50% of the root surface is a 2 reaction, root rot covering 51-89% of the root surface is a 3 reaction, and rot on >90% of the root surface or the plant is dead represents a 4 reaction. By multiplying the data by 7/4, a comparison can be made between the data obtained using the 0-4 scale with that using the 0-7 scale employed at the Fort Collins disease nursery.

The results in Table 1 are for a minimum of 50 roots tested per accession per trial. Ranking of the germplasm accessions according to percent healthy roots and disease index clearly was similar to that for the same accessions in the root rot nursery at Fort Collins, CO. Mean DI ratings for accessions FC907 and FC718, which exhibit moderate resistance, varied the greatest between experiments. Consistently low DIs were observed for the highly resistant accession FC709-2, in agreement with the performance of this accession in the field nursery. Accession FC403, produced from parents having resistance to beet curly top virus, exhibits poor resistance to root rot in the field. This is revealed in the inoculations of greenhouse-grown plants as well.

The results validate the evaluation of root rot resistance by inoculation of greenhouse-grown sugarbeet roots at 5 weeks of age. It is stressed that both highly resistant and highly susceptible check accessions or varieties always should be included in the study as experimental controls. Seed from a mapping population developed by J.M. McGrath (ARS-East Lansing) and segregating for resistance to Rhizoctonia root rot will be evaluated in 1999 using the greenhouse method. Highly resistant and highly susceptible progeny from the cross will be used to identify molecular genetic markers that co-segregate with root rot resistance. Use of such markers could significantly reduce costs in a breeding program, by substituting marker detection for disease screening.

Table 1. Evaluation of sugarbeet for resistance to Rhizoctonia root rot using by plant inoculation in the greenhouse.

	Greenhouse Experiments								Field Nursery							
	Disease rating								FC'94		FC'95		FC'96		FC'97	
Germplasm accession or hybrid	0	1	2	3	4	Total	% hlthy[1]	DI[2]	% hlthy (86/5)[3]	DI (1.0/4.9)	% hlthy (64/2)	DI (1.3/4.5)	% hlthy (100/30)	DI (0.9/2.9)	% hlthy (49/0)	DI (2.5/6.7)
Maribo 'Ultramono'	0	2	7	20	21	50	4	5.6								
FC604	0	4	7	13	26	50	8	5.6	15	4.8						
FC403	2	1	3	7	37	50	6	6.2			12	3.1				
FC907	3	9	2	7	29	50	24	5.3			11	3				
FC718	14	28	3	2	3	50	84	1.6	75	1.4	61	1.5	80	1.3		
FC709-2	29	9	5	6	1	50	76	1.4	86	1	55	1.3	100	0.9	49	2.5
Maribo 'Ultramono'	0	1	1	0	58	60	2	7								
FC403	2	3	2	14	45	66	8	6.1								
FC907	0	2	1	1	56	60	3	6.7								
FC718	5	16	3	4	32	60	35	4.7								
FC709-2	51	3	3	0	0	57	90	0.3								
Maribo 'Ultramono'	0	0	1	7	32	40	0	6.6								
FC403	1	1	0	0	36	38	5	6.7								
FC907	8	2	5	20	5	40	25	4								
FC718	7	11	9	3	10	40	45	3.9								
FC709-2	21	10	2	3	3	39	80	1.6								

[1]Percent healthy plants is derived from the number of plants within the 1 and 2 classes divided by the total number of roots rated for an accession.
[2]Disease index (DI) produced by the multiplication of the raw data by 7/4 for conversion to the 0-7 scale.
[3]Highest and lowest numbers over all accessions rated for the given year in the Fort Collins nursery are presented in parentheses.

POLYMERASE CHAIN REACTION (PCR)-BASED DETECTION OF APHANOMYCES COCHLIOIDES USING ACTIN GENE SEQUENCES

Project 620

J.J. Weiland

A number of soil fungi have the capability to cause disease in sugarbeet and these include *Rhizoctonia solani*, *Aphanomyces cochlioides*, *Pythium aphanidermatum*, *P. ultimum*, and *Fusarium oxysporium*. When seedling damping off or adult plant root rot occur, diagnosis of the causal agent of the disease can be a time-consuming process (days to weeks). Culture of the organisms from an infected area of the sugarbeet root can lead to the recovery of a plethora of fungi, many of which have colonized the infected tissue as saprophytes.

The polymerase chain reaction (PCR) is a DNA based technique for amplifying specific sequences from the genomes of organisms. PCR technology has impacted many fields of biology, including the area of disease diagnosis in both plants and animals. Diagnostics using the PCR are sensitive and highly discriminatory, since they target genome regions whose DNA sequences have diverged throughout evolution. PCR-based diagnostics also require little time for a result to be secured (within one to two days), making them attractive to high-throughput diagnostic laboratories.

The interests in our laboratory include the development of novel diagnostic tools for disease-causing fungi in sugarbeet, as well as the development of tools for investigating the biochemistry of sugarbeet pathogenesis by fungi. For this reason, we designed our PCR assay for the discrimination of sugarbeet fungal pathogens upon DNA sequences of the actin gene. Actin is a protein found in all eukaryotes and the gene coding for actin possesses sequence blocks of both high similarity, as well as of high divergence, across all eukaryotes. This facilitates the design of DNA "primers" that recognize the highly similar sequences in order to detect potential size variation in the actin gene that can be used to "fingerprint" and discriminate one sugarbeet pathogen from another. Actin is also a highly expressed gene and the cloning and re-engineering of actin gene sequences might provide a useful tool for gene transfer studies with sugarbeet fungal pathogens.

In 1998, the PCR discrimination was tested for the ability to distinguish *A. cochlioides* from the common legume pathogen, *A. euteiches*. Since sugarbeet can be grown in rotation with, or in close proximity to, dry bean, alfalfa, and other legumes, it is important to be able to distinguish these two pathogens. Primers based on the actin gene when used in the PCR amplify a product from *A. cochlioides* that is indistinguishable from that amplified from *A. euteiches*. Digestion of the amplified product with restriction endonucleases that possess 4-base recognition sequences, however, generates a fingerprint that clearly distinguishes the two pathogens (Fig. 1). It is proposed that sufficient divergence between the two pathogens has occurred that is reflected in sequence, but not size, variation in the actin gene. The nucleotide substitutions that reflect this divergence in the actin gene will be analyzed by DNA sequencing in 1999. New primers then will be synthesized that permit the two pathogens to be distinguished without the need for pathogenicity testing.

Experimental controls where PCR with the actin gene primers was applied to sugarbeet DNA indicated that, using primer annealing conditions that permit the amplification of actin sequences

from *A. cochlioides*, no products were produced from sugarbeet DNA. From this information, I decided to test the ability for the PCR to detect *A. cochlioides* in diseased sugarbeet seedlings, without prior culture of the fungus. The results in Figure 2 clearly demonstrate that *A. cochlioides* can be detected in diseased seedlings, where as no DNA amplification was apparent for samples prepared from healthy seedlings harvested in the same trial. These results hold promise for the development of rapid diagnostics for the identification and sensitive detection of fungal pathogens in diseased sugarbeet tissues. Ultimately, protocols will be produced for the detection of pathogens in the soil.

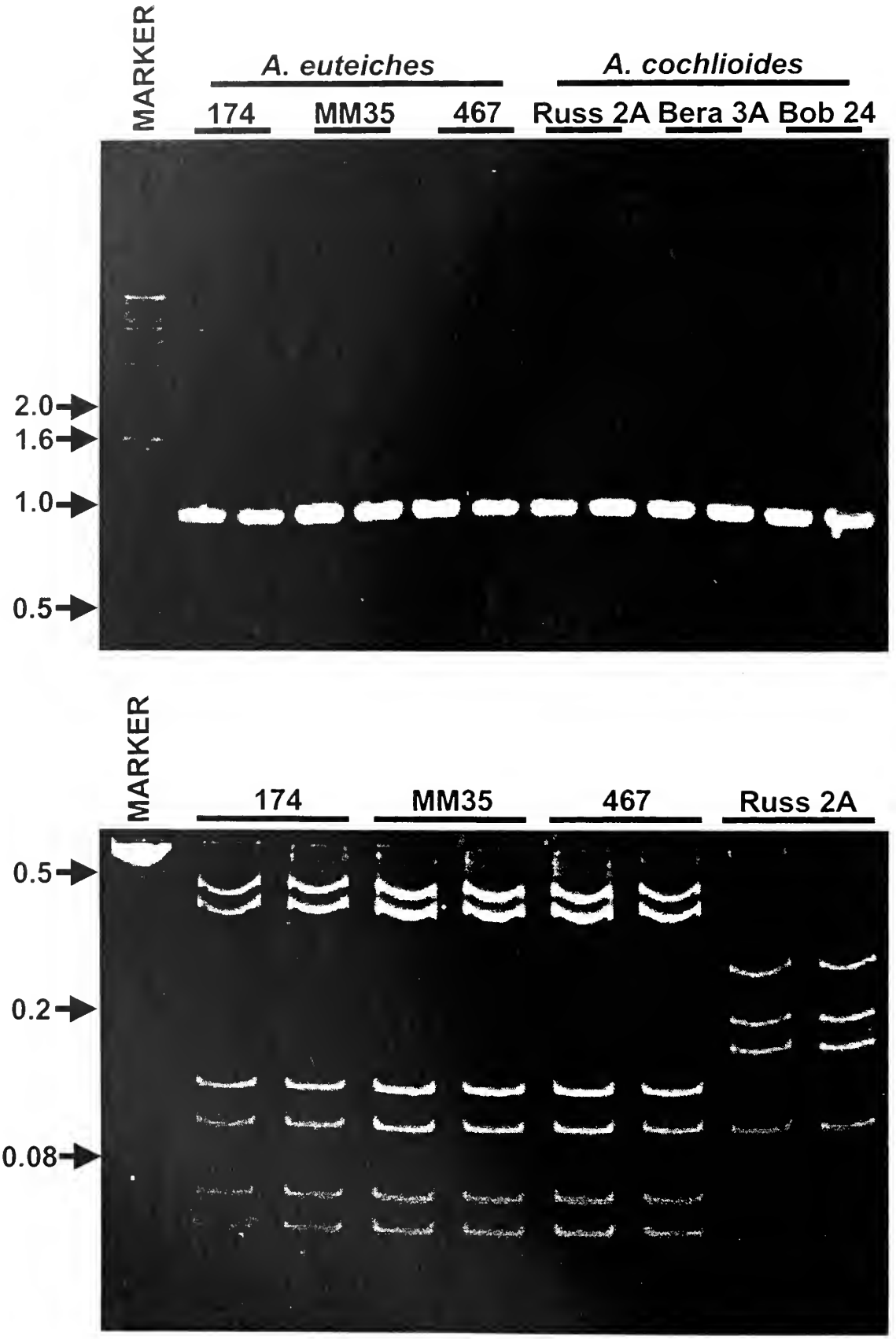
MARKER
A. euteiches
A. cochlioides
174
MM35
467
Russ 2A
Bera 3A
Bob 24
2.0
1.6
1.0
0.5
MARKER
174
MM35
467
Russ 2A
0.5
0.2
0.08

Figure 1

Figure 1. Amplification of actin gene sequences from *A. cochlioides* and *A. euteiches* and DNA fingerprint profiles produced by amplified product digestion. In the top panel, 3 isolates each of *A. cochlioides* and *A. euteiches* were sources of DNA for the amplification by PCR of actin gene sequences using the primers 5FWDACT and MIDREVACT. Products from the amplification were separated on a 1% agarose gel, stained with ethidium bromide and photographed. Note that the size of the products is indistinguishable using this detection system. In the bottom panel, a subset of the products show in the top panel were digested with a mixture of the restriction endonucleases *Alu* 1, *Hae* III, and *Msp* 1. Digested products were fractionated on a 5% polyacrylamide gel, stained with ethidium bromide, and photographed. Note the DNA fingerprint pattern consistency within the *A. euteiches* isolates and how this pattern differs from that generated by the *A. cochlioides* isolate Russ 2A.

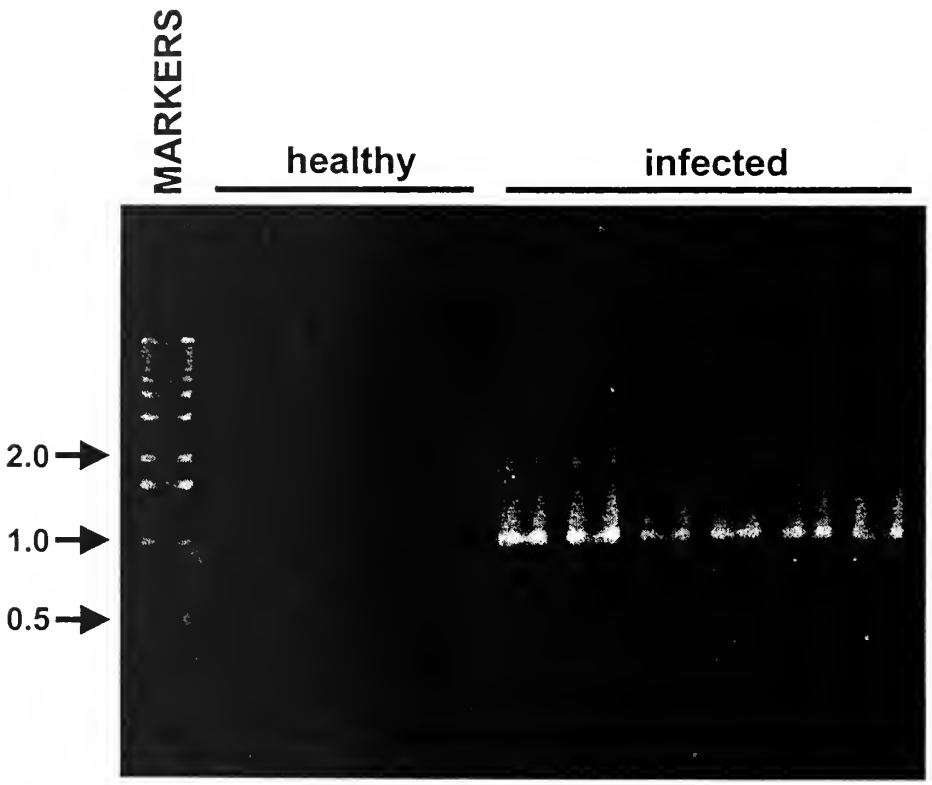

Figure 2. Detection of *A. cochlioides* in diseased sugarbeet seedlings. Extracts from healthy and diseased seedlings of sugarbeet 'Ultramono' were added to reaction mixes for PCR amplification. Primers 5FWDACT and MIDREVACT, which are targeted to the actin gene of *A. cochlioides* were used in the reaction. Products of the amplification were separated on a 1% agarose gel containing Tris-borate EDTA buffer. Products were stained with ethidium bromide and photographed. The amplified product in the diseased sample lanes is of the same size as that amplified from the DNA prepared from pure cultures of *A. cochlioides*. The 1 kb marker ladder (Life Technologies, Inc.) was co-electrophoresed as a size standard.

THE DEVELOPMENT OF DYNAMIC GENE POOLS FROM *BETA MARITIMA* SOURCES

Project 630

Larry G. Campbell

Since heterosis generally is enhanced by increasing the genetic diversity of the parents, the introduction of desirable germplasm from previously unused sources is essential to the success of long-range hybrid development programs. Because of its background and the need for specific characteristics such as cytoplasmic male sterility, monogerm, and different disease resistances, the sugarbeet breeding pools are believed to be genetically limited. Although there appears to be sufficient variability for short term gains, long term progress may very well depend upon the infusion of additional variation into the crop.

Potential sources of genetic variation not now being utilized fully include 1) old land races of sugarbeet, table beet, and fodder beet; 2) new naturally occurring or induced mutations; and 3) wild relatives. New sources of genetic variation should produce fertile offspring when crossed with sugarbeet and be genetically unique and diverse, compared to commercial sugarbeet. Of the wild relatives, *Beta maritima* best fits these criteria. In its native habitat, *B. maritima* persists in numerous environments. Its adaptation to this range of environments has resulted in the accumulation of stress response traits different from cultivated beet. Over the past 20 years many representatives of this species have been collected, preserved, and made available to breeders. Several breeders (Manerati, Dahlberg, Lewellen, and Doney) have successfully incorporated genes from this wild form into sugarbeet.

The objective of this research project is the development of populations that incorporate some of the genetic diversity from wild *Beta* into sugarbeet. The goal is to produce populations with root characteristics and sucrose concentrations similar to commercial sugarbeet.

Crosses Between Released Fargo Lines and L19

Y317, y318, y322, and y387 are released germplasms all derived form the cultivated / maritima cross, L53 / PI 546420. PI 546420 was collected near Thessaloniki, Greece in 1978. It is a multigerm, non-O type, annual with prostrate growth habit. Testcross hybrids between the released lines and L33 were deficient in sucrose concentration, compared with commercial hybrids. Because of this it was decided to cross the above germplasm lines to L19. L19 is noted for its ability to produce hybrids with relatively high sugar concentrations. Its parentage includes the Polish variety 'Udyca'.

Fifty-six families (entries) were grown at Prosper, North Dakota in 1996 Each entry traced back to a single selfed F_1 plant with the pedigree: L53cms / PI 546420 // L19.. These families had an average sugar content of 13.3%; ranging from 8.4 to 15.9%. Recoverable sugar per ton of beets ranged from slightly below 100 to 298 lbs. per ton with an average of 237 lbs. per ton.

Individual roots of all entries were sampled for sucrose concentration. The mean of the 842 roots sampled was 14.56%. Entry means of the 56 entries ranged from 10.7 to 17.1% sugar. Selection was based upon both family mean and individual root sucrose within a family. The selected families had means greater than 14.4%. Individual root sucrose concentrations ranged from 7.4 to 19.4% prior to selection. Selected roots ranged from 14.6 to 19.4% with a mean sugar percent of 16.1% or 1.6% higher than the unselected roots. 339 roots from 30 entries were selected for increase.

Each of the 30 selected entries was maintained as an entity. Eight to 15 roots were selected from each entry for increase in the greenhouse (1997). Seed from plants within an entry (average of 11 plants / entry) was bulked for testing in replicated field tests in 1998. Data from the 1998 trial was of limited value because of conditions related to the extremely wet spring of 1998. These 30 families will be evaluated in replicated trials again in 1999.

Crosses of Miscellaneous wild *Beta* with Sugarbeet

The sugarbeet parent in these crosses was a California line (3747) segregating for genetic male sterility. Crosses were made on male sterile segregates. In subsequent intercrosses, seed was harvested from male sterile segregates to maintain the sterility and insure intercrossing. After two cycles of random intercrossing all populations were grown in a space planted nursery and selected for root shape. Lines that performed well in testcrosses (L33cms) in 1996 were increased and evaluated again in replicated trials in 1997. Eleven of the 18 lines tested were increased in the summer of 1998. These will be evaluated as lines in replicated trials in 1999. Some will be examined in testcross hybrids and others used as parental material in the formation of new populations.

Recent Introductions to the Breeding Program

Population were formed by crossing a self incompatible sugarbeet line from California (R376-43) with thirty-seven wild *Beta* accessions from the United Kingdom, France, Ireland, Denmark, Belgium, and the Channel Islands. Ten plants from each wild accession were crossed (as pollinators) individually to R376-43. Ten F_1 plants from each cross (100 plants) were intercrossed to produce the F_2 generation. Equal numbers of seeds from each F_2 plant were grown and intercrossed to produce the F_3 seed. Selection for root shape was initiated with the 1998 crop. Selected plants are now being increased in the greenhouse to produce seed for a second cycle of selection for root shape in 1999.

NOVEL FUNGAL PATHOGEN FOR THE BIOLOGICAL CONTROL OF THE SUGARBEET ROOT MAGGOT

Project 642

G.A. Smith, J.J. Weiland, and J.D. Eide

Current methods for detection and identification of entomopathogenic fungi are laborious and time consuming, and identification of different strains of the same fungal species is even more difficult. Attempts at the genetic characterization of *Metarhizium anisopliae* (Metschnikoff) Sorokin have included the use of randomly amplified polymorphic DNA (RAPD), restriction fragment length polymorphism analysis (RFLP) analysis, and others. These studies have met with limited success. *M. anisopliae* have been collected for studying genetic polymorphisms using rRNA analysis and mtDNA RFLP. The objective of this study was to prepare PCR (polymerase chain reaction) primers specific for the detection of strains of *M. anisopliae* that are pathogenic to the sugarbeet root maggot. The entomopathogenic fungi examined in this study included *Beauveria bassiana*, *Cordyceps militaris*, *Hirsutella thompsonii*, *M. anisopliae*, *M. flavoviride*, *Syngliocladium tetanopsis* and *Verticillium lecanii*. In addition, the following ATCC strains of *Metarhizium* were used: ARS-T1 (fungi re-isolated from third instar sugarbeet root maggots inoculated with *M. anisopliae* 22099), 16085, 38630, 56096, 62176, 60335 and 32969. All fungal cultures were grown in 50 ml of 1% peptone, 2% dextrose broth. The DNA was extracted from each and PCR was carried out using standard procedures in a Perkin Elmer thermocycler. The PCR products were separated in agarose gels. The DNA fragments were cloned into an Invitrogen plasmid pCR2.1 and the resulting plasmid transformed into *Escherichia coli* TOP10F's using the manufacturer instructions. Plasmid DNA was isolated using an alkaline lysis PEG 8000 precipitation method. DNA was sequenced at the Iowa State University DNA Sequencing facility.

PCR primers specific for the 5' end (5FWDACT) and 3' end (MIDREVACT) of the actin gene coding sequence were synthesized. These primers were used in the PCR to amplify a 1.3-kb DNA fragment in *M. anisopliae* ARS-T1 and five other *M. anisopliae* strains (Fig. 1). These same primers detected a 1.2-kb fragment in the entomopathogenic fungi *B. bassiana*, *C. militaris*, *H. thompsonii*, and *V. lecanii*. Digestion of the 1.3 kbp PCR actin products with *Aci* I, *Alu* I and *Sau* 3A I showed variation between *Metarhizium* strains (Fig. 2). The *M. anisopliae* fragments were cloned and both strands sequenced. In order to obtain the complete nucleotide sequence two primers internal to the 1.3-kb actin fragment were synthesized. These primers were used in the PCR with *M. anisopliae* DNA and amplified a 450-bp fragment that was cloned and sequenced. The intron sequences are being examined for unique sequences specific for *M. anisopliae*. The rRNA genes of these fungi also are being examined for the presence of distinguishing sequence characteristics. Two primers, ITS1 and ITS4 specific for the ITS (Internal transcribed spacers) region of the nuclear rRNA gene were synthesized. Use of these primers in the PCR with *M. anisopliae* DNA produced a 600-bp fragment(Fig. 3). We have also synthesized two primers E24 and PN29 for use in amplification of the 28S rDNA. The primers amplified a 1.1-kb fragment from DNA of *M. anisopliae* in all strains tested except ATCC 38630. These primers amplified larger fragments of approximately 2 kpb in *C. militaris*, *B. bassiana* and *V. lecanii*. *S. tetanopsis* produces a 500 bp fragment with the E24 and PN29 primers. This fragment contains group I introns which have been useful for differentiating between strains of entomopathogenic fungi. Use of PCR with the above sets of primers will help

differentiate entomopathogenic fungal species.

New strains of *M. anisopliae* are being tested as a biocontrol agent for control of *Tetanops myopformis* (Sugarbeet Root Maggot). Loss of chemical controls and variable results with chemical controls led us to examine biological control measures. Our previous studies have shown the efficacy of the entomopathogenic fungi ARS-T1 (*M. anisopliae*) on first instar SBRM (Sugarbeet root maggot), third instar SBRM and adult flies.

We are continuing to examine long-term viability of *B. bassiana* and *M. anisopliae.* The fungi are stable under many types of storage conditions tested to date(table 1).

Production of *M. anisopliae* conidia on heat killed barley is being fine tuned. We have been able to produce conidia on heat killed barley with two strains of *M. anisopliae.* A different strain of *M. anisopliae* with better laboratory efficacy is being produced for field application. This strain is being produced with a cooperator as a granular and a sprayable powder for field application in 1999. This strain of *M. anisopliae* (62176) can produce over 10^8 conidia per petri plate. We have previously shown that field efficacy can occur at 10^{13} conidia per acre.
Production of conidia and blastospores using air batch cultures and fermentation is also being examined. This will facilitate application technologies for delivery of *M. anisopliae* in a practical and economically feasible method to grower fields .

Table 1. Viability of *B. bassiana* and *M. anisopliae* under different temperature regimes (+ = still viable, - = not viable, Nd = not determined).

Fungus Tested and Temperature		Months				
		5	34	45	47	58
M. anisoplaie	20°C	+	+	+	+	-
"	-20° C	+	+	+	Nd	+
"	-80° C	+	+	+	Nd	+
B. bassiana	20°C	+	+	+	+	-
"	-20° C	+	+	+	Nd	+
"	-80° C	+	+	+	Nd	+

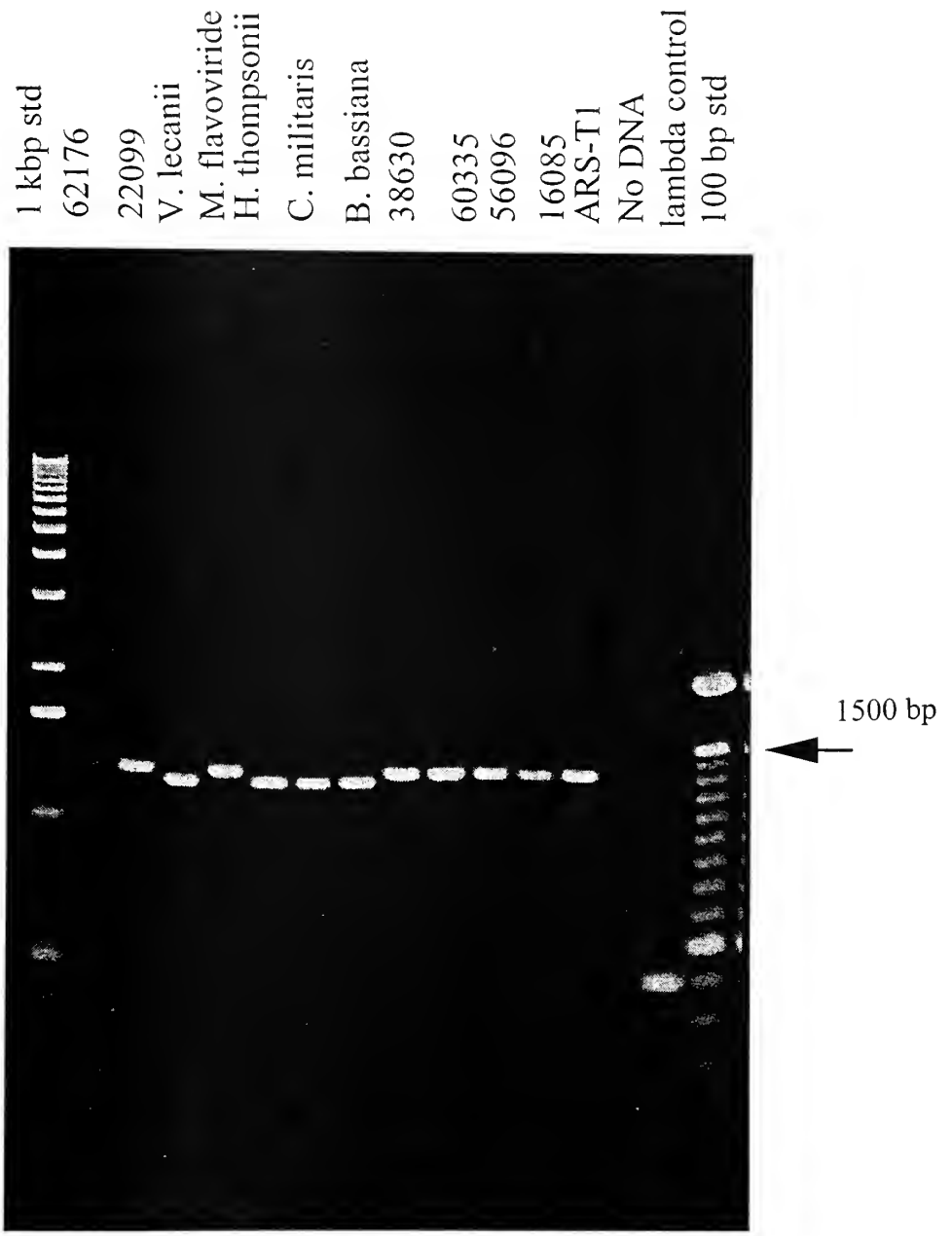

Fig. 1. A 1% agarose gel showing PCR products produced with 5fwdact & midrevact primers using entomopathogenic fungal DNA. The PCR reaction conditions were 94° C 2 min. followed by 40 cycles of 94° C 1 min, 37°C 1 min. and 72° C 2 min., then 72°C for 7min. Two microliters of PCR product was loaded per lane. Ten microliters of a 1 to 20 dilution of std DNA was loaded on opposite ends of the gel.

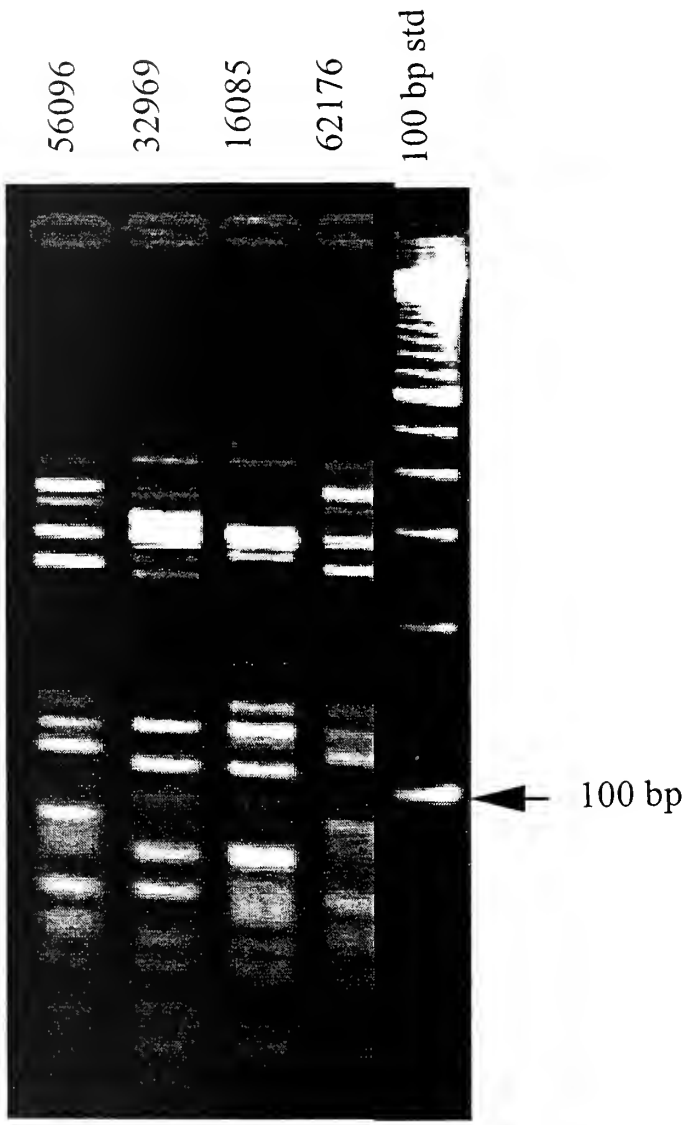

Fig. 2. A 3% MetaPhor agarose gel with PCR products of 5fwd and midrev actin primers digested with Aci I, Alu I and Sau 3A I. The PCR reaction conditions were 94°C 1min., then 94° C, 30 sec, 40° C 2 min.,72° C 30 sec for 40 cycles followed by 72° C for 7 min. A total of 25 microliters was loaded per lane. Ten microliters of a 1 to 10 dilution of 100 bp standard was loaded as a marker.

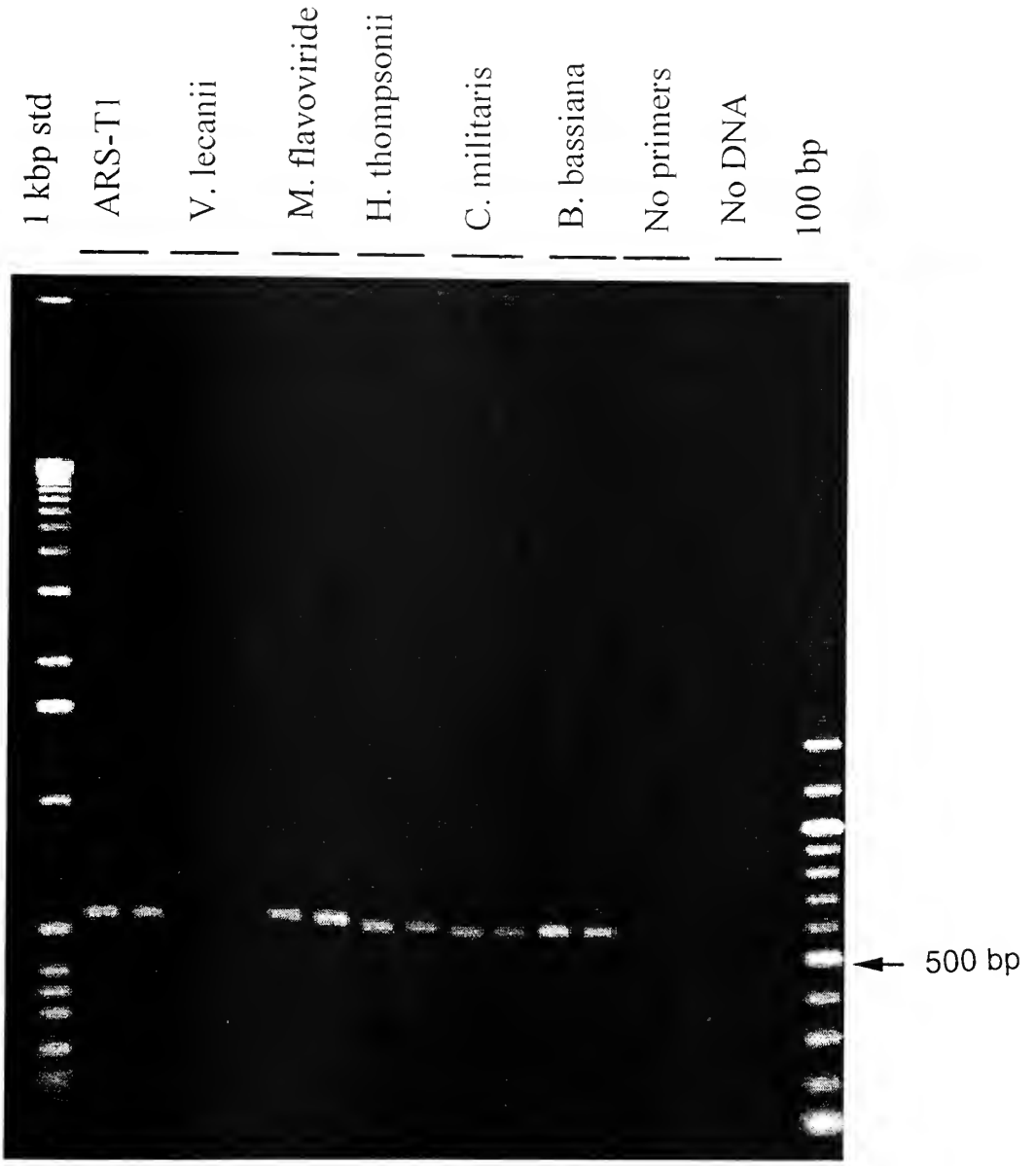

Fig. 3. A 1% agarose gel showing PCR products produced with rRNA primers ITS1 & ITS4 using entomopathogenic fungal DNA. The PCR reaction conditions 94°C 1 min. 94° C then 40 cycles of 94° C 1 min., 45° C 1 min., 72° C 2 min. followed by 72° C for 5 min. Ten microliters of the reaction was loaded on to gel.

IDENTIFICATION OF THE SUCROSE METABOLIZING ENZYMES RESPONSIBLE FOR SUCROSE LOSSES DURING SUGARBEET DEVELOPMENT AND STORAGE

K.L. Klotz

Optimizing sucrose accumulation in the sugarbeet root and preventing sucrose degradation during sugarbeet root storage are important for the profitability of the sugar industry. The accumulation and maintenance of high sucrose levels in roots benefit the grower and processor alike. Labor, capital and transportation costs decrease with increased sugar content. Processing losses also decline when a high sucrose content is obtained and maintained. High sucrose content is positively correlated with better storage and processing characteristics. Maintaining a high sucrose content is also important since degradation of sucrose to the invert sugars, glucose and fructose, increases color formation during extraction and causes the loss of sucrose to molasses during crystallization.

While the importance of producing a sugarbeet root that can accumulate and maintain high sucrose levels is well recognized, our understanding of the biochemical and physiological processes involved in obtaining such a sugarbeet is limited. The enzymes involved in sucrose formation and degradation are well known. Sucrose is synthesized in the leaves by sucrose phosphate synthase and sucrose phosphatase. Sucrose not needed by the leaf for its own metabolic needs is transported through the plant's vascular system upward to the growing shoot tip or down into the root. In the root, sucrose may be catabolized to provide for the root's energy and material needs or it may be sequestered in the vacuole of root parenchyma cells for storage. Three major enzymes are responsible for sucrose catabolism in the root. They are the acid invertases, alkaline or neutral invertases and sucrose synthase. It is the objective of ongoing and future research at the USDA/ARS Northern Crop Science Laboratory in Fargo, ND to understand the function of these sucrose catabolizing enzymes in sugarbeet roots and determine their contribution to sucrose losses during root development and postharvest storage.

The biochemistry of the sucrose catabolizing enzymes is well known. The invertases catalyze the hydrolysis of sucrose to glucose and fructose. Invertases are classified according to their pH optimum for activity. The acid invertases exhibit optimal enzyme activity at pH 4.5-5.0. They are found in the vacuole or the cell wall where they can be insolubilized by ionic bonds. Neutral or alkaline invertases exhibit greatest activity at pH 7.0-8.0 and are localized in the cytoplasm. Generally, acid invertase activity is associated with young growing tissues. Neutral or alkaline invertase activity is typically low in young tissues and increases with tissue maturity. Sucrose synthase is the third major sucrose catabolizing enzyme. Sucrose synthase catalyzes the reversible transfer of a glucose residue from sucrose to uridine diphosphate (UDP) to produce fructose and UDP-glucose, a metabolically active form of glucose. Sucrose synthase activity is localized in the cytoplasm and is positively correlated with sink strength.

Although the biochemistry of the sucrose catabolizing enzymes is well defined, their function in sugarbeet sucrose metabolism is uncertain. Many studies have attempted to define their role in the sugarbeet root by correlating enzyme activity with sucrose content or sucrose losses. The results from these studies, however, have often been ambiguous and contradictory. The very nature of the

sucrose catabolizing enzymes may be responsible for the difficulty in determining their function. In nearly all plants, invertase and sucrose synthase occur not as single enzymes, but as families of isoenzymes. Isoenzymes within a family typically exhibit different patterns of expression, and often exhibit different reactivities toward substrates and products. Different isoenzymes are important at different developmental stages and are thought to have separate functions in the plant. Previous studies into the role of the sucrose catabolizing enzymes have relied almost exclusively on enzyme activity assays. These assays measure total activity for an enzyme family, but are unable to differentiate the activity of individual isoenzymes. This experimental approach has probably contributed to the uncertainty over the function of these enzymes.

At the NCSL, studies are underway to determine the role of the individual isoenzymes of acid and alkaline invertase and sucrose synthase in sucrose losses. The activity of individual isoenzymes of the sucrose catabolizing enzymes is being determined throughout sugarbeet root development and postharvest storage under favorable and unfavorable conditions. The levels of these isoenzymes will be correlated with changes in root carbohydrate content and respiration rate. Sucrose, glucose and fructose levels at all stages of growth and storage will be measured as well as the respiration rate of roots in postharvest storage. Future studies will also correlate steady state transcript levels for the individual isoenzymes with changes in carbohydrate content and respiration rate. These studies should provide clues to the importance of different isoenzymes in sucrose losses during growth and postharvest storage. Comparison of enzyme activity and steady state transcription levels for the individual isoenzymes will also provide insights into their regulation.

It is hoped that the knowledge gained from these studies will aid in maximizing extractable sucrose from sugarbeet roots. An understanding of the contribution and regulation of the different sucrose catabolizing isoenzymes to sucrose losses may provide insights into changes in cultural or storage practices to enhance sucrose accumulation and preservation. Alternatively, these studies may identify specific isoenzymes whose expression could be altered by genetic engineering to increase extractable sucrose levels in sugarbeet roots.

SUGAR BEET RESEARCH

1998 REPORT

Section E

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CONTENTS

Sugar beet activities of the USDA-ARS East Lansing conducted in cooperation with Saginaw Valley Bean and Beet Farm during 1998

OVERVIEW

The USDA-ARS conducted seven trials at the Bean and Beet Farm in 1998. Four of these trials were designed to examine seedling emergence and stand establishment. Two of these trials are reported here (Tests 9812BB and 9813BB). Of the other two trials not reported, one was a non-replicated observation nursery and one was a double-blind evaluation strictly for emergence performance. Two additional trials for agronomic evaluation of germplasm in development in the USDA-ARS East Lansing program were conducted, and these are reported here (Tests 9814BB and 9815BB). The final test was an attempt at developing an Aphanomyces nursery on the farm. From the standpoint of seedling disease, the test was not informative.

The 1998 sugarbeet field trials at the Bean and Beet Research Farm near Saginaw were planted in Range 8, tiers 7 through 10. This land had been in dry beans in 1997. The soil was prepared by fall plowing, followed by frost tillage in the early spring. Beets were planted on April 28, 1998. Pre-emergence herbicide (3 qt. Pyramin and 2 qt. Nortron SC per acre) was banded onto the rows immediately following seeding. Seed germination was not as good overall as observed in 1997. Plots were thinned to 6 to 8" between plants within the row and weeded by the second week of July, generally resulting in good plant stands after thinning and weed control. All experiments were machine harvested October 13 and 14, 1998. Sugar analysis was generously provided by the Michigan Sugar Co. sugar laboratory and their assistance is greatly appreciated.

All statistical analyses were performed with the aid of MSTAT and / or JMP. Differences between means were determined with Duncan's Multiple Range test, and judged significantly different by different letter suffixes following the means in the tables.

TEST 9812BB: FIELD EVALUATION OF EMERGENCE I: REPLICATED TRIALS OF A RANGE OF SUGAR BEET AND RELATED GERMPLASM

J. Mitchell McGrath, Cathy A. Derrico, Yi Yu and Richard A, Kitchen
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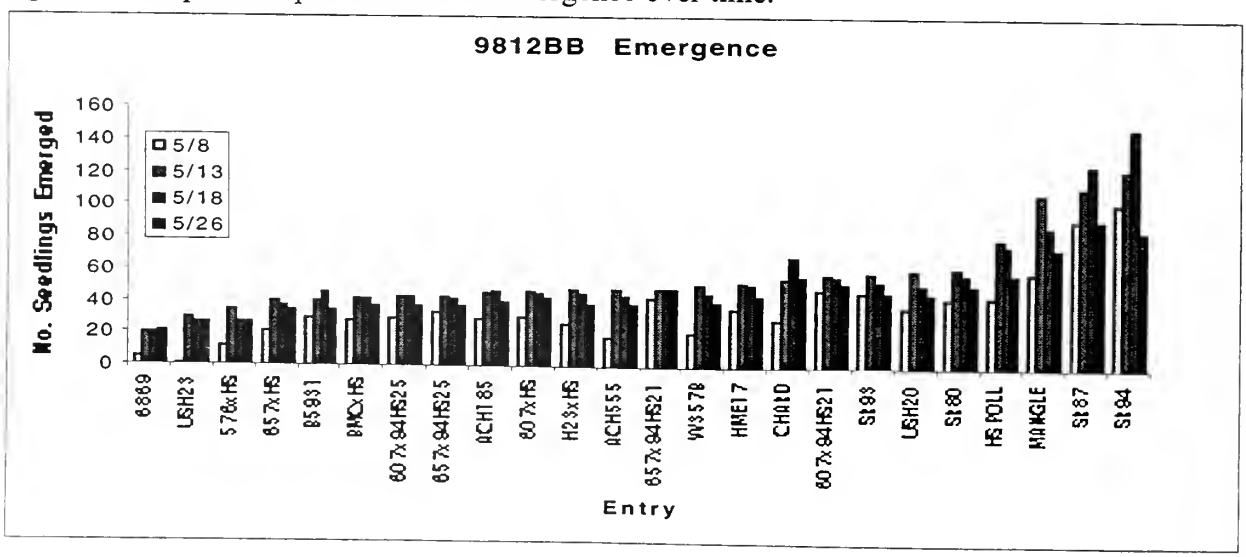
The objective of this test was to examine field emergence in a range of sugar beet and related materials for eventual correlation with laboratory germination in aqueous solutions. The materials examined included four current commercial seedlots, four smooth-root germplasm releases (prefix SR), two obsolete USDA hybrids, one accession each of red beet, fodder beet and Swiss chard, 10 monogerm experimental hybrids and one line from USDA Salinas, CA. It is important to note that these accessions were a mix of both monogerm and multigerm seed. Emergence counts were taken five times during the emergence phase, beginning May 6, 1998, but only the last four readings are reported since few seedlings were evident on May 6 (<1 seeding per plot on average). Emergence values are reported in Table 1, with accessions arranged in order of increasing mean emergence over the whole test. Significant differences in emergence were observed, both within and among monogerm and multigerm accessions, however a great deal of variability was also evident despite eight replications of the trial.

Table 1: Mean emergence for Test 9812BB. Test was planted in four two-row experimental unit of 100 seeds per row, with each row treated as an independent replicate.

Entry	Type	May 8	May 13	May 18	May 26	Mean	Std Dev
6869	monogerm	5.6	20.6	20.6	22.1	17.3	7.8
USH23	monogerm	2.0	29.5	26.5	26.5	21.1	12.8
576xHS	monogerm	12.5	35.4	27.6	27.3	25.7	9.6
657xHS	monogerm	21.6	40.8	38.4	34.6	33.8	8.5
BMCxHS	monogerm	28.3	41.6	42.1	38.1	37.5	6.4
ACH555	monogerm	19.5	48.4	44.6	39.6	38.0	12.9
B5931	monogerm	30.0	41.1	46.1	35.5	38.2	7.0
607x94HS25	monogerm	30.4	42.8	43.1	37.9	38.5	5.9
657x94HS25	monogerm	33.3	42.9	41.8	38.0	39.0	4.3
W357B	multigerm	21.1	51.0	46.0	40.8	39.7	13.1
H23xHS	monogerm	26.8	48.3	45.6	39.9	40.1	9.6
ACH185	monogerm	30.4	46.3	47.8	40.6	41.2	7.9
607xHS	monogerm	31.5	47.5	46.6	43.0	42.2	7.4
HME17	monogerm	36.1	53.4	51.0	44.4	46.2	7.7
657x94HS21	monogerm	42.9	49.0	48.6	48.7	47.3	3.0
USH20	monogerm	37.8	60.4	52.0	45.5	48.9	9.6
SR93	multigerm	47.5	60.3	54.4	47.0	52.3	6.3
CHARD	multigerm	30.3	55.9	68.8	56.6	52.9	16.2
607x94HS21	monogerm	48.4	58.3	57.0	52.4	54.0	4.5
SR80	multigerm	44.0	63.0	58.5	51.1	54.2	8.4
HS POLL (92HS25)	multigerm	45.0	80.1	76.5	57.8	64.8	16.5
Fodder (Mangle)	multigerm	59.4	109.1	88.8	74.0	82.8	21.2
SR87	multigerm	92.3	112.1	125.9	92.3	105.6	16.4
SR94	multigerm	103.5	123.3	148.5	84.9	115.0	27.3
CV (%)		29	34	47	25		
LSD (0.05)		11.2	19.8	27.1	12.1		

Figure 1: Graphical representation of emergence over time.



An ancillary goal of this test was to determine agronomic performance of fodder beet (designated mangle in these experiments), red beet and Swiss chard in a sugar beet growing regime. Table 2 reports the combined agronomic results. Due to their small size, Swiss chard roots from all replicates were combined for sugar analysis. However, it is evident that the sucrose content of Swiss chard is comparatively high among non-sugar beet materials.

Table 2: Agronomic performance for Test 9812BB arranged in order of decreasing RWSA.

Entry	RWSA		RWST		T/A		Suc %		CJP %		NH2	
B5931	**7256**	A	276.2	A	26.27	ABC	**18.83**	A	94.46	A	154.3	DEF
HME17	**7254**	A	264.7	A	27.39	AB	**18.27**	A	93.98	ABC	179.3	CDEF
657x94HS21	**6965**	AB	239.5	CD	29.10	A	**17.06**	BCD	92.84	ABC	221.0	BCDE
657x94HS25	**6855**	ABC	237.2	CD	28.89	A	**16.98**	BCD	92.61	ABC	220.8	BCDE
657xHS	**6149**	ABCD	224.2	CDE	27.43	AB	**16.14**	CDEF	92.52	ABC	222.8	BCDE
USH20	**6084**	ABCDE	235.9	CD	25.73	ABCD	**16.39**	CDEF	94.01	ABC	183.6	CDEF
ACH555	**6015**	ABCDEF	260.1	AB	23.05	BCDE	**17.83**	AB	94.43	AB	200.4	CDEF
H23xHS	**5585**	BCDEF	229.5	CDE	24.31	ABCDE	**16.12**	CDEF	93.62	ABC	181.5	CDEF
BMCxHS	**5448**	CDEFG	231.1	CDE	23.70	ABCDE	**16.52**	CDE	92.77	ABC	278.0	AB
607xHS	**5198**	DEFGH	231.7	CDE	22.51	BCDEF	**16.30**	CDEF	93.51	ABC	182.5	CDEF
SR93	**5044**	DEFGHI	195.0	F	25.69	ABCD	**14.40**	G	91.90	C	213.0	BCDE
607x94HS21	**4921**	DEFGHIJ	239.8	CD	20.43	DEFGH	**16.80**	BCD	93.62	ABC	158.3	DEF
SR94	**4848**	DEFGHIJ	245.0	BC	19.83	EFGH	**17.00**	BCD	94.00	ABC	171.5	CDEF
USH23	**4793**	DEFGHIJ	220.0	DE	21.56	CDEFG	**15.58**	EF	93.39	ABC	176.5	CDEF
607x94HS25	**4627**	EFGHIJ	226.9	CDE	20.22	DEFGH	**15.94**	CDEF	93.71	ABC	178.0	CDEF
ACH185	**4591**	EFGHIJ	225.5	CDE	20.31	DEFGH	**16.06**	CDEF	93.06	ABC	129.8	F
HS POLL	**4549**	FGHIJ	242.6	BC	18.79	EFGHI	**17.15**	BC	93.12	ABC	178.0	CDEF
576xHS	**4045**	GHIJ	213.7	E	18.56	EFGHI	**15.24**	FG	93.20	ABC	150.2	EF
SR80	**3933**	HIJ	232.9	CDE	16.88	FGHI	**16.22**	CDEF	94.00	ABC	132.5	F
SR87	**3674**	IJ	224.2	CDE	16.47	GHI	**15.88**	DEF	93.31	ABC	160.5	DEF
6869	**3433**	J	219.5	DE	15.64	HI	**15.98**	CDEF	92.12	BC	246.0	ABC
W357B	**1570**	K	111.2	G	13.70	I	**9.78**	H	87.03	D	303.1	A
Fodder (Mangle)	**1507**	K	106.5	G	13.90	I	**9.72**	H	85.50	D	231.5	BCD
CHARD(est)					4.54	J	**13.80**	I				

Overall, there was no apparent relationship between emergence and agronomic performance, although for commercial materials better emergers tended to yield higher. Rankings of emergence among accessions was similar to that observed in the 1997 field trail (for those accessions in common, e.g. US H23 < ACH 185 and B5931 < Novartis E17 < US H20).

A series of crosses were made by J.C. Theurer (retired) in 1993 as a test for combining ability. These materials were included to compare emergence of different hybrids (e.g. 657xHS, H23xHS, 607xHS, 576xHS and BMCxHS) created with the same pollinator (e.g. HS = 92HS25) grown in the same environment. Significant differences between the hybrids for emergence was not evident, although significant differences for agronomic performance were observed.

FIELD EVALUATION OF EMERGENCE II: REPLICATED TESTS OF IDENTICAL VARIETIES GROWN IN DIFFERENT ENVIRONMENTS.

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The objective of this test was to examine field emergence among different seedlots of the same commercial variety. Three varieties were available in which seedlots had been obtained in the same year from more than one grower (via the West Coast Beet Seed, Co., Salem, OR). Additional seedlots from different years were available in some instances, as well. All seedlots were commercially prepared by the Michigan Sugar, Co. and Monitor Sugar, Co. seed plant, and their efforts in securing these seeds and their seed multiplication location are gratefully acknowledged. Field data was gathered for comparisons with germination data in liquid media (data not shown).

For emergence (Table 1) no significant statistical differences were evident between seedlots of the same variety grown in the same year, however variability between replications was high in all cases despite eight replications of the trial. Significant differences between varieties were evident.

Table 1: Mean emergence in Test 9813BB. The first two digits of the lot number indicate year of production. Different lot numbers within the same year were grown in different commercial production fields. One variety with an unknown year of production was used to balance the test. Test was planted in four two-row experimental unit of 100 seeds per row, with each row treated as an independent replicate.

Entry	Lot #	May 8	May 13	May 18	May 26	Mean	Std Dev
E17	950533	41.9	57.6	55.0	48.4	50.7	8.7
E17	960003	45.9	61.4	57.0	51.9	54.0	9.5
E17	960001	44.1	56.8	53.5	49.3	50.9	8.4
E17	960013	38.1	52.0	50.9	47.9	47.2	7.7
E17	960017	31.3	48.6	47.0	45.4	43.1	10.0
E17	960015	31.8	45.6	45.3	41.5	41.0	9.3
E17	960019	28.4	45.8	45.6	42.3	40.5	9.2
E17	970095	37.5	51.5	50.3	47.9	46.8	7.2
ACH308	950312	41.3	50.6	46.9	44.4	45.8	6.6
ACH308	960009	29.8	49.5	48.0	45.5	43.2	10.4
ACH308	950772	33.0	45.0	44.5	42.1	41.2	10.0
E4	unknown	22.8	44.6	41.6	41.4	37.6	11.3
E4	93514	14.8	40.0	39.1	35.9	32.4	11.3
E4	931138	10.0	29.8	28.4	27.8	24.0	9.2
CV (%)		22	14	13	14		
LSD (0.05)		7.2	6.9	6.7	6.5		

Agronomic performance (Table 2) did not appear to be correlated with emergence, although the best yields (RWSA) were seen with the best emergers. However, the relative emergence of the two remaining varieties was opposite in rank to their agronomic performance.

Table 2: Agronomic performance for Test 9813BB arranged in order of decreasing RWSA.

Entry	Lot	RWSA		RWST		T/A		Suc %		CJP %		NH2	
E17	960001	**7432**	A	275.0	AB	27.14	A	**18.82**	A	94.32	A	148.5	A
E17	960017	**7394**	AB	282.2	A	26.16	AB	**19.34**	A	94.14	A	174.8	A
E17	950533	**7311**	AB	272.3	ABC	26.85	A	**18.64**	AB	94.32	A	154.5	A
E17	960019	**7310**	AB	277.4	AB	26.33	AB	**19.10**	A	93.98	A	174.0	A
E17	960015	**6897**	AB	272.0	ABC	25.31	AB	**18.71**	AB	94.08	A	152.0	A
E4	unknown	**6880**	AB	253.8	BC	27.11	A	**17.87**	AB	93.16	A	162.5	A
E17	970095	**6851**	AB	274.2	AB	24.94	AB	**18.90**	A	93.96	A	132.8	A
E4	93514	**6812**	AB	263.1	ABC	25.94	AB	**18.26**	AB	93.74	A	179.3	A
E4	931138	**6669**	AB	269.8	ABC	24.68	AB	**18.45**	AB	94.39	A	178.0	A
E17	960003	**6629**	AB	269.7	ABC	24.50	AB	**18.43**	AB	94.45	A	162.0	A
ACH308	960009	**6075**	ABC	265.3	ABC	22.90	ABC	**18.44**	AB	93.72	A	124.6	A
E17	960013	**5873**	ABC	260.8	ABC	22.43	ABC	**17.97**	AB	94.12	A	129.1	A
ACH308	950312	**5799**	BC	259.8	ABC	22.08	BC	**18.00**	AB	93.97	A	165.8	A
ACH308	950772	**4895**	C	248.1	C	19.46	C	**17.14**	B	94.21	A	120.3	A

EXPERIMENT 9814BB: AGRONOMIC EVALUATION OF SMOOTH ROOT RELEASES AND PROSPECTIVE RELEASES.

Joseph W. Saunders, J. Mitchell McGrath and Richard A. Kitchen
USDA-Agricultural Research Service,
Cooperative with
Department of Crop and Soil Sciences

This experiment was designed to evaluate performance for the standard agronomic parameters as well as suture prominence score. Tested germplasm included three commercial hybrid varieties (ACH555, B5931, HME17), the 1998 East Lansing ARS smoothroot release SR95 (96HS20-7), two 1997 East Lansing ARS smoothroot releases (SR93 and SR94), two older East Lansing ARS smoothroot releases (SR87 and SR80) from 1992 and 1990 respectively, and four prospective East Lansing ARS smoothroot releases (96HS5, 96HS15, 96HS25, 97HS21-7). The four remaining entries were a smoothroot developmental population (WC970307, aka 96J09-2,), 97J27-00 (a three-way clone hybrid with two smoothroot parents), 96RM10-02 (a

smoothroot high sugar developmental line segregating for Rhizomania resistance), and 98J11-011 (an F_2 population of a cross between SP550-01 and SR95. The three 1997-98 releases and the four prospective releases are derived from the East Lansing ARS breeding program of J.C. Theurer, now retired, that combined eastern US smoothroot sugarbeet germplasm with high sucrose percentage germplasm lacking tolerance to diseases in the Great Lakes production area. This was a six-replicate, four-row test with harvest of the middle two rows only.

The summary table for Experiment 9814BB is ordered by Recoverable White Sugar per Acre (RWSA) performance. When sucrose percentages are examined, the three commercial hybrid checks form the leading cluster. The extremely smoothroot entries SR87 and SR93 group at the bottom for sucrose %, consistent with past performances. In general, the historical pattern of inverse relationship between sucrose percentage and root smoothness is seen in this test, although 1998 release SR95 and prospective release 97HS21-7 have root smoothness nearly as great as released germplasms SR87 and SR93.

Table 1: Agronomic performance of lines in Test 9814BB.

Entry	RWSA		RWST		T/A		Suc %		CJP %		NH_2		Suture	
HME17	**7426**	A	272.3	AB	27.27	A	**18.87**	A	93.74	ABCD	160.2	CDEFG	2.50	A
97J27-00	**6875**	AB	238.0	D	28.02	A	**17.13**	CDE	92.34	D	256.4	A	1.92	BC
ACH555	**6812**	AB	275.9	A	24.61	AB	**18.52**	AB	95.30	A	174.5	BCDEFG	2.50	A
B5931	**6576**	ABC	260.2	BC	25.24	AB	**17.89**	BC	94.32	ABC	123.0	G	2.50	A
96RM10-02	**6009**	BCD	239.5	D	25.16	AB	**17.10**	CDE	92.68	CD	215.2	ABC	2.00	B
SR94	**5981**	BCD	241.2	D	24.68	AB	**16.91**	DE	93.61	BCD	175.7	BCDEFG	1.83	BCD
96HS20-7 (SR95)	**5653**	BCDE	237.0	D	23.75	ABC	**16.49**	DE	93.99	ABC	198.8	ABCDE	1.54	DE
96HS25	**5371**	CDE	246.6	CD	21.15	BCD	**17.12**	CDE	93.99	ABC	151.6	DEFG	1.79	BCD
98J11-011	**5158**	DE	246.7	CD	20.92	BCD	**17.20**	CD	93.72	ABCD	231.0	AB	1.96	B
97HS21-7	**5158**	DE	237.1	D	21.79	BCD	**16.50**	DE	93.98	ABC	148.5	EFG	1.46	E
SR80	**5038**	DE	231.7	DE	21.70	BCD	**16.22**	EF	93.76	ABCD	154.0	CDEFG	1.58	DE
SR87	**4815**	DE	220.6	EF	21.95	BCD	**15.55**	FG	93.62	BCD	186.3	BCDEF	1.63	CDE
96HS5	**4696**	DE	257.0	C	18.30	D	**17.38**	CD	95.14	AB	133.2	FG	1.83	BCD
96HS15	**4694**	DE	239.8	D	19.58	CD	**16.98**	CDE	93.10	CD	214.0	ABCD	1.92	BC
96J09-2	**4635**	E	237.5	D	19.57	CD	**16.83**	DE	93.07	CD	210.2	ABCDE	2.33	A
SR93	**4632**	E	211.9	F	21.62	BCD	**15.02**	G	93.52	BCD	173.0	BCDEFG	1.54	DE

EXPERIMENT 9815BB: AGRONOMIC EVALUATION OF SMOOTH ROOT DEVELOPMENTAL POPULATIONS, PROSPECTIVE RHIZOCTONIA RESISTANCE RELEASES, AND HYBRIDS OF SP550.

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Cooperative with
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The objective of this test was to evaluate advanced breeding lines for agronomic performance. Two commercial lines, three East Lansing germplasm releases, and 10 experimental lines were examined.

Description of entries:

ACH555	American Crystal commercial cultivar
HMI E17	Novartis Seeds Hilleshog commercial cultivar
SR93	ARS-EL smoothroot release
98J26-052	Pprospective RZT-APH-CER resistance mm release
WC92408	Theurer 1992 'Oregon Composite' germplasm mixer
97J51-00	F_2 of high sugar SR clone and mm near-Type-O clone
98EL50	EL50; mm APH-CER resistance, some RZT resistance
550cmsX98EL50	Hybrid of SP550cms X EL50
98J09-00	F_2 of mm SR clone and mm RZT resistance population
98J18-00	F_2 of MM SR clone and mm RZT resistance population
98J19-01	F_2 of AA-1 and AA-2 SR clones from 95H07 population.
550cmsX98J19	Hybrid of SP550cms X 98J19-01
98J27-00	Complex F_2 of three-way hybrid with 50% 95H07
98RR	Newly released as EL51 RZT-CER resistant multi-mono
550cmsX96RR	Hybrid of SP550cms X EL51

RZT = Rhizoctonia, CER = Cercospora, APH = Aphanomyces

The commercial cultivar checks HM E17 and ACH555 occupied the two top positions for SUC%, and HM E17 was significantly the highest recoverable white sugar per acre (RWSA, Table 1). Percent sucrose (SUC%) was the focus of this test, and entries based on traditional East Lansing germplasm generally scored in the 15.5-16.3% SUC range. Entries with some background of high SUC% (such as 97J51-00, WC92408 and 98J27-00) fell into the 16-17% SUC range. Hybrids of 96RR and 98J19 with the higher SUC% SP550cms had considerably higher SUC% than the corresponding pollinator entries. The hybrid of 98EL50 with SP550cms had an equivalent SUC% to the pollinator entry, but still in the range of the other two SP550cms hybrids. SP550-0 is being considered as a source of adapted high SUC% germplasm for improving sugar % without sacrificing resistance to Aphanomyces or Cercospora.

Perhaps the most interesting result of the test was that the two highest tonnage entries (98J19-01 and 98J27-00) in the test had at least 50% of their germplasm from the SR source line 95H07. Furthermore, the highest tonnage entry in test 9814BB also had 50% of its germplasm from 95H07. All three entries had one SR parent clone in common. Collaterally, all three entries were low in clear juice purity (CJP%) and/or high in amino-N.

A similar but larger grouping of the 95H07-derived entries is seen from the RWSA ordering in tests 9814BB and 9815BB. In that case, one (97J27-00) of the two top entries in test 9814BB was a 95H07 derivative, and three of the top four entries in test 9815BB were 95H07 derivatives, when counting 98J19x3, which is 550-cms X 98J19-01. Another way of viewing the grouping is knowing that there were only four 95H07 derivatives entered in the total of the two tests. 95H07 is a derivative of a cross of EL50 X SR selections from WC91034M.

Table 1: Agronomic performance of lines in Test 9815BB. Entry 97J03-00 failed to emerge.

Entry	RWSA		RWST		T/A		Suc %		CJP %		NH_2	
E17	**7154**	A	261.1	A	27.37	ABC	**18.06**	A	93.95	A	213.2	DEF
98J27-00	**6247**	B	223.9	CD	28.00	AB	**16.21**	CDEF	92.26	EFG	235.7	CDE
98J19x03	**5991**	BC	232.9	BC	25.74	ABCD	**16.61**	BC	92.84	BCDE	222.3	CDEF
98J19-01	**5879**	BCD	208.9	F	28.30	A	**15.64**	DEF	91.04	H	275.3	BC
SR93	**5569**	BCD	222.1	CDE	25.08	ABCDE	**15.63**	DEF	93.65	AB	215.7	CDEF
WC92408	**5527**	BCD	227.4	CD	24.24	BCDEF	**16.11**	CDEF	93.24	ABCD	174.8	EF
98J26-052	**5507**	BCD	210	EF	26.25	ABC	**15.49**	EF	91.64	GH	355.0	A
550cmsx96RR	**5505**	BCD	232	C	23.65	CDEFG	**16.41**	CD	93.27	ABCD	186.8	EF
ACH555	**5245**	CDE	244.5	B	21.40	EFGHI	**17.20**	B	93.34	ABC	234.7	CDE
98EL50	**4991**	DEF	226.4	CD	22.03	DEFGH	**16.26**	CDE	92.61	CDEF	236.2	CDE
98J18-00	**4945**	DEFG	223.9	CD	22.10	DEFGH	**16.17**	CDEF	92.40	DEFG	170.8	F
97J51-00	**4427**	EFG	228.9	CD	19.37	HI	**16.62**	BC	92.07	EFG	264.8	BCD
98J09-00	**4313**	EFG	215.7	DEF	19.98	GHI	**15.45**	F	92.91	BCDE	207.0	DEF
98RR	**4261**	FG	204.3	F	20.89	FGHI	**14.74**	G	92.78	BCDE	171.7	F
550cmsxEL50	**4022**	G	223.3	CD	17.97	I	**16.30**	CDE	91.91	FG	305.7	AB
97J03-00	**0**	H	0	G	0.00	J	**0.00**	H	0.00	I	0.0	G

IN VITRO SYSTEMS FOR SUGARBEET INTERACTION WITH RHIZOCTONIA, CERCOSPORA, PYTHIUM AND APHANOMYCES PATHOGENS OF BEET.

Joseph W. Saunders and Peter S. Hudy

Research in the last year has included evaluation of mycelial growth of *Cercospora beticola* (CER) and *Pythium ultimum* (PYT) on nitrogen variations of the standard Murashige-Skoog (MS) medium we use for culture of various sugarbeet tissues, much like the initial evaluations of mycelial growth of *Rhizoctonia solani* (RZT) and *Aphanomyces cochlioides* (APH) reported last year. Although for each pathogen a single isolate from sugarbeet was used, the use of four pathogens evaluated in similar manner has introduced the concept of comparative studies of pathogen-sugarbeet interactions that has prospects for greater understanding of pathogen action when incorporated into factorial experiments with combinations of genetic resistance to one or more pathogens. Issues such as effectiveness of host resistance against spores versus mycelium, and tissue specificity of resistance, may also be addressable in an *in vitro* culture system.

The best way to comprehend the current status of this research thrust is to summarize the findings for each of the four pathogens. RZT and PYT grew well (about 2 cm/day) from mycelial plugs on Murashige-Skoog agar medium with standard 60 mM nitrogen from nitrate and ammonium (all media contained 3% sucrose as carbon and energy source). This rapid growth rate quickly covered the plate in two days or less. Mycelial growth of both RZT and PYT was similar with 60 mM nitrogen (N) from either nitrate or ammonium alone to that with the standard MS N mix, indicating ability of these two pathogens to grow well on minimal forms of nitrogen.

On the other hand, mycelium of *Cercospora beticola* (CER) grew more slowly (about a tenth as fast), and *Aphanomyces cochlioides* (APH) spread rapidly but sparsely on MS medium with standard N mix of nitrate and ammonium. Each of these growth habits (slow growth of CER, sparse growth of APH) may be suitable for use in culturing sugarbeet tissue in the same petri dish or flask as pathogen mycelium, especially if modifications of the medium can be worked out to further restrict mycelial growth.

Progress in that direction was achieved with APH. It was discovered that APH growth was negligible on standard MS medium without agar (ie, liquid on a shaker), and also when more refined kinds of agar were used instead of the usual Difci Bacto agar. This suggested that impurities in the Bacto agar were permitting the sparse growth to occur. Further experiments with various N and sulfur (S) sources have strongly suggested that APH isn't capable of chemically reducing the very basic nitrate and sulfate forms of N and S found in MS medium (and that sugarbeet tissues and RZT, PYT and CER can ably assimilate).

These latter experiments had two complications. First, it was difficult at first to assess the effectiveness of various N sources before it was realized that a reduced sulfur source such as thioglycolate or methionine was also required. Secondly, basal growth in some experiments could have depended on low quantities of reduced N or S brought in with the water agar (Bacto!) mycelial inoculum plug.

This apparent inability of APH to reduce nitrate and sulfate has several implications. First is that minimal growth of APH in cultures containing beet tissue should be possible by using a

purified form of agar for both the main medium and for the water agar used to prepare the mycelial inoculum plugs (cylinders cut from the agar). Second is that APH as a member of the soil microflora may have limited ability to grow saprophytically, contrary to what's understood for RZT and PYT, which probably use nitrate as the predominant N source during their saprophytic growth. Extending this, it may be valid to exclude effects of rotation on quality and quantity of organic matter as having a direct role in control of APH, and think more of effects of better weed control or rotation to reduce oospore and zoospore concentrations in the sugarbeet crop.

With CER, growth with nitrate or ammonium as sole N source was greater than growth on the standard MS mix. This seems a little unusual, but was very repeatable.

What did these pathogens do when inoculated on the other side of the Petri dish from sugarbeet callus, leaf disc or fibrous root masses growing on standard MS agar medium? RZT and PYT quickly overran the entire agar surface and the beet tissue; the beet tissue did not remain alive. APH mycelia grew sparsely toward the beet tissue, growing in density when contacting the proximal area of the tissue, then overrunning it slowly. Such a system might be useful if further modifications can be worked out, perhaps involving less sucrose in the medium.

The most interesting interaction seen in these preliminary experiments occurred with CER. When several inoculum plugs were placed on the far side of the plates from the single leaf discs, the CER mycelia slowly grew outward to a diameter of about one cm, then appeared to stop surface growth and grow sparsely beneath the surface of the agar. When it came within about a centimeter of the senescing leaf disc, the sparse mycelium appeared to hit the zone of biological exudates from the disc, and produced the conspicuous red color of the phytotoxin cercosporin (the plates had been growing in the lab light). My interpretation of this was that CER mycelia were unable to produce cercosporin initially from the inorganic nitrogen in the MS medium, but did produce cercosporin when nutrition from proteins exuded from the leaf discs were encountered. Differential response to different carbon/nitrogen environments could be another interpretation.

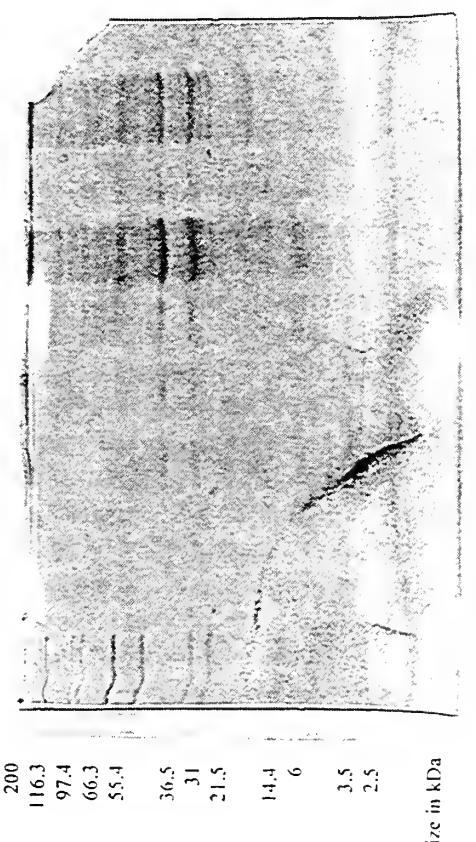
Another approach to co-culturing CER with sugarbeet leaf discs was taken by placing a single mycelial agar plug on top of the leaf disc (genotype REL-1), in the middle. Within a few days a necrotic 'hole' had been burned down through the disc, without spreading laterally. Next, the mycelium spread along the agar surface underneath the leaf disc, then spread over the disc after appearing from beneath the underside of the disc. This system may have prospects for comparing genotypes because the initial growth of CER is slow (it does not start out in contact with the medium), and the initial damage to the discs if limited and slow to develop, on the time scale of days.

Co-culture of pathogen and host plant tissue in vitro offers prospects for studying host defense gene expression, and opportunities for identification and cell selection of resistant genotypes, but pathogen growth characteristics on the medium used to culture the host tissue can determine the feasibility of such systems. From the research summarized above, APH and CER would appear to be the two pathogens with the most potential to be used in co-culture research. APH would appear amenable to somatic cell selection, especially with use of purified agar to restrict myceliar growth in the presence of sugarbeet tissue. Because APH is primarily a seedling

disease, the novel use of germinating somatic embryos as "seedlings" to identify somaclonal variants at the (small) whole plant level is anticipated.

RZT or PYT, on the other hand, would have to be used differently in a sugarbeet tissue culture context because of their rapid growth on standard MS agar medium. We have demonstrated toxicity of RZT culture medium filtrate (CF) to plated suspension cells of sugarbeet (clone REL-1). Recently we adapted a polyacrylamide gel electrophoresis (PAGE) system for protein separation and staining to visualize proteins in the RZT-CF liquid. As little as 30 microliters of CF from sixteen day cultures of RZT growing on sugarbeet cell walls produced up to a dozen protein bands, probably soluable hydrolytic enzymes (see accompanying figure).

SDS-PAGE of *Rhizoctonia solani* Culture Filtrate



PNL standard

RZT 26d

MS0 26d

RZT 16d

MS0 16d

RZT 5d

MS0 5d

RZT 2d

MS0 2d

molecular weight standards

PRESENTATIONS AT SCIENTIFIC MEETINGS:

"Differential growth of sugarbeet root pathogens *Rhizoctonia solani* and *Aphanomyces cochlioides* on nitrogen variations of Murashige-Skoog medium for development of co-culture systems" at the IX International Congress on Plant Tissue and Cell Culture in Jerusalem in June 1998.

"Growth of sugarbeet pathogens Cercospora beticola and Pythium ultimum on variations of Murashige-Skoog medium for development of co-culture systems" at the annual meeting of the American Society of Agronomy in Baltimore in Oct 1998.

NOTICE OF RELEASE OF SR95 SMOOTH ROOT SUGARBEET GERMPLASM

Sugarbeet (*Beta vulgaris* L.) germplasm SR95 (Reg. No. GP- , PI 603947) was developed by the USDA-ARS and the Michigan Agricultural Experiment Station, in cooperation with the Beet Sugar Development Foundation, and released in December 1998. SR95 has excellent root smoothness, equivalent to SR87 (3) but with at least 5% higher sucrose concentration than SR87. SR95 has significantly smoother roots than SR94 (1) released earlier from related parentage. The smoothroot characteristic reduces soil quantities taken from the field on harvested beets, as well as subsequent soil disposal costs as industrial waste at the sugar factory (3). Smoothroot sugarbeets also are prospective components of redesigned sugarbeet harvesting and piling systems that reduce bruising and subsequent storage-pile sugar losses due to rot and respiration.

SR95 resulted from two successive open-pollination increases of half-sib seed produced on a single mother beet selected for extreme root smoothness from the population that later was released as SR94 (1). That single mother beet had been open-pollinated by seven other beets mass-selected for elite root smoothness and conical shape, each stemming from different complex but related parentages that as a group combined high sucrose concentration germplasms L19 (2), C40 and C51, curly-top-resistant L35cms (2) and L53 (2), and smoothroot germplasms SP85700-0 (3), SP85131-0 and SP8530-0 from the former USDA breeding program of G. Coe at Beltsville. L19 (PI 590690), C40, C51 and SP85700 (PI 590776) also comprise most of the parentage of SR94. C40 (8400040) and C51 (8400051) are high sucrose percentage lines kindly provided by Crystal-Maribo Seeds. L19, L35cms (PI 590840) and L53 (PI 590841) were developed for the intermountain region by the former USDA breeding program at Logan UT.

SR95 is diploid multigerm and segregates for red and green hypocotyl color. SR95 is relatively easy bolting, and male-fertile plants are largely self-sterile with a significant degree of pseudo-self-fertility under individual plant isolation. Male-sterility exceeds thirty percent, and is thought to be derived from L19. SR95 has been tested under the East Lansing seed number 96HS20-7 where it yielded sucrose concentrations 108, 106, 96, and 91 percent of that of SR87, SR93, SR94, and the mean respectively of that of three commercial cultivars ACH185 (American Crystal), B5931 (Betaseed) and HME17 (Hilleshog-Novartis) at Saginaw MI in 1997. In that same test, SR95, SR87, SR93, SR94 and the threesome of commercial cultivars had smoothroot scores (0 = no grooves, branch roots or fibrous roots on the beet; 4 = deep grooves, at least one branch root and plentiful fibrous roots) of 1.75, 1.63, 1.63, 2.21 and 2.79, respectively.

Cercospora leaf spot (*Cercospora beticola* Sacc.) disease index (average for three dates) for SR95 at the USDA-ARS evaluation at Ft. Collins CO in 1997 was 4.83 compared to 3.28, 3.94 and 6.50 for the resistant line EL50, SR94 and the susceptible check, respectively, on a scale of 0 to 7 ($LSD_{0.05} = 0.9$). In the 1997 Betaseed root rot evaluation at Shakopee MN, which largely measures response to *Aphanomyces cochlioides* (Drechs.), SR95 had a moderately resistant stand rating (3.1 compared with 3.7, 4.5 and 5.7 for the resistant Michigan hybrid check, SR94 and the susceptible Canadian hybrid check, respectively, on a scale of 1 to 9; $LSD_{0.05} = 1.17$).

SR95 provides an additional germplasm source for developing smoothroot breeding lines or cultivars. Seed will be maintained by USDA-ARS and is available for use by writing to Dr. J. Mitchell McGrath, USDA-ARS, Crop and Soil Science Department, Michigan State University, East Lansing, MI 48824-1325. Genetic material of this release has been deposited in the National Plant Germplasm System where it is available for research purposes, including development and commercialization of new cultivars.

J.W. Saunders*, J.M. McGrath, J.M. Halloin, and J.C. Theurer

References and Notes

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2. Theurer, J.C. 1978. Registration of eight germplasm lines of sugarbeet. Crop Sci. 18:1101.
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The technical assistance of Rick Kitchen and Peter Hudy is gratefully acknowledged.

NOTICE OF RELEASE OF EL51 SUGARBEET GERMPLASM WITH RESISTANCE TO RHIZOCTONIA CROWN AND ROOT ROT

Sugarbeet (*Beta vulgaris* L.) germplasm EL51 (Reg. No. GP-, PI 598074) was developed by the USDA-ARS and the Michigan Agricultural Experiment Station, in cooperation with the Beet Sugar Development Foundation, and released in January 1999. EL51 was released because it has extremely high resistance to crown and root-rotting strains (AG-2-2) of *Rhizoctonia solani* Kühn. EL51 was developed at the Sugarbeet and Bean Research Unit, East Lansing, Michigan by the sugarbeet breeding team of Drs. J.M. Halloin, J. C. Theurer (now retired), J.W. Saunders, and J. M. McGrath. EL51 also has moderate to good resistance to Cercospora leaf spot caused by *Cercospora beticola* Sacc. and to blackroot seedling disease and root rot caused by *Aphanomyces cochlioides* Drechs., and is an expected source for development of multigerm and monogerm parental lines for hybrid cultivars resistant to three of the most destructive sugarbeet diseases in the United States.

EL51 is predominantly multigerm with 11 percent monogerm plants. It is non-Type-O, self-sterile, and segregates for red and green hypocotyls. EL51 resulted from an initial hybridization of four plants of FC705/1, selected for resistance to Rhizoctonia crown and root rot at East Lansing in 1985, with a heterogeneous pollinator population of 87 plants. This group of males was composed of 15 mass selected plants from an increase of FC701/5 mass selected at East Lansing for resistance to Rhizoctonia crown and

root rot, and 72 plants from ten families (81B19, 82B18, 83B8, 84B5, 84B6, 84B7, 84B8, 84B9, 84B10, 84B11) of the traditional East Lansing germplasm pool, both multigerm and monogerm, some with Rhizoctonia resistance breeding history. These 72 plants had been mass selected for resistance to Rhizoctonia crown and root rot or to Cercospora leaf spot. Seven of the resulting F_1 plants were chosen by mass selection for resistance to Rhizoctonia crown and root rot at East Lansing in 1987, and intercrossed to produce a population that was subjected to two consecutive cycles of recurrent selection for resistance to Rhizoctonia crown and root rot at East Lansing, with no less than twenty selected beets intercrossed in each generation. The resulting population was tested under the designation 96RR. EL51 resulted from the seed increase of 96RR for release purposes.

EL51 is highly resistant to Rhizoctonia crown and root rot, scoring a disease index (DI) significantly more resistant than resistant checks FC705/1 and FC712 (1.70 compared with 2.40 and 2.23, respectively; DI of 0 = no root rot, and 4 =all plants dead; $LSD_{0.05} = 0.38$) in the1997 USDA-ARS commercial cultivar evaluation at East Lansing. EL51 resistance to Cercospora leaf spot is moderately good, with EL51 receiving a 3.11 mean score compared with 2.83, 2.89, and 4.22 (DI of 0 = no leaf spots and 7 = all plants dead; $LSD_{0.05} = 0.84$) for the resistant check, EL50, and the susceptible check, respectively at the 1998 USDA-ARS evaluation at Ft. Collins. EL51 had a stand rating of 3.4 (moderately resistant) compared with 2.5 and 3.7 for SR87 and the resistant Michigan hybrid check in the 1997 Betaseed summer root rot (Aphanomyces) evaluation at Shakopee MN (DI of 0 = full healthy stand, and 9 = all plants dead; $LSD_{0.05} = 1.17$).

EL51 has been tested under the identification 96RR where it yielded sucrose concentrations 88 percent of the mean of that of two commercial cultivars ACH185 (American Crystal) and HME17 (Hilleshog-Novartis) in three tests at Saginaw MI in 1996 and 1997.

EL51 provides a germplasm source for the development of elite monogerm and multigerm parental lines and populations with resistances to crown and root rot and leafspot diseases. Breeder seed will be maintained by USDA-ARS and will be provided in quantities adequate for reproduction. Written requests should be addressed to Dr. J. Mitch McGrath, USDA-ARS, Sugarbeet and Bean Research Unit, Department of Crop and Soil Sciences, Michigan State University, East Lansing MI 48824. Genetic material of this release has been deposited in the National Plant Germplasm System where it will be available for research purposes, including development and commercialization of new cultivars. It is requested that appropriate recognition be made if this germplasm contributes to genetic research or to the development of a new breeding line or cultivar.

J.M. Halloin, J.W. Saunders*, J.C. Theurer, and J.M. McGrath

The technical assistance of Robert Sims and Rick Kitchen is gratefully acknowledged.

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Use of Seed Mixtures of *Rhizoctonia*-Resistant and Susceptible Sugarbeet Varieties for Control of Crown and Root Rot.

BSDF Project 720

John M. Halloin and David J. Johnson, Agricultural Research Service, U. S. Department of Agriculture, Sugarbeet and Bean Research Unit, Department of Botany and Plant Pathology, Michigan State University, East Lansing, MI 48824-1312, and Steve Poindexter, Michigan State University, Agricultural Extension service, Saginaw, MI.

Background:

Recently, Rhizoctonia-resistant sugarbeet varieties with yields and sugar concentrations approaching, but not equaling those of other commercial varieties have become available to Michigan sugarbeet growers. These have been recommended for planting under conditions where severe crown and root rot problems are anticipated.

The pattern of disease development for crown and root rot typically observed is one in which several to many contiguous plants within a row, or within a few adjacent rows are diseased, with plants in other adjacent rows remaining non diseased. This pattern of disease development suggests that the fungus spreads through the soil, and is able to surmount the gap between plants within a row more easily than the larger gap between rows.

It was proposed that use of mixtures of seeds from both resistant and susceptible varieties would allow interdiction of this spread with resistant varieties, thereby limiting spread of the disease. Experiments were done in 1998 at two locations to determine the effect of such seed mixtures on the occurrence of crown and root rot, and on yield of sugarbeets.

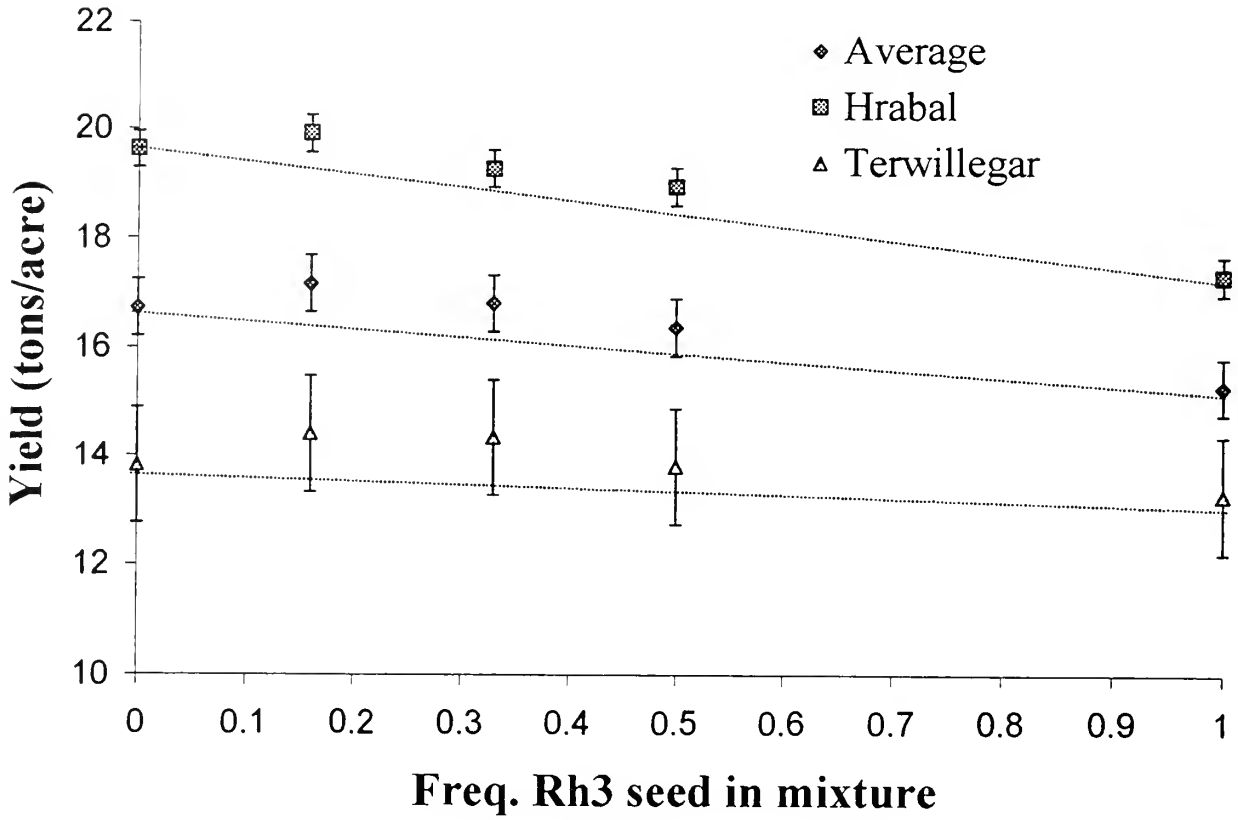
Results:

The effect of planting seed mixtures on yields is summarized in the graph on the next page. The lines drawn between points representing 100 percent E17 and 100 percent RH3 represent the yields that would be anticipated from mixtures if use of mixtures had no effect on yields. All points representing yields attained with mixtures were above these theoretical lines, indicating that there were beneficial effects of planting mixtures. Actual counts of dead and diseased plants throughout the season (data not presented) showed small differences between treatments in numbers of dead plants, however, there were no statistically significant differences in numbers of contiguous plants killed or diseased at individual disease sites. Additionally, most plants succumbed to the disease simultaneously, indicating that plant-to-plant disease development is of little importance.

Discussion:

The effects of planting seed mixtures on yield showed statististically significant benefits of this practice. However, the observed pattern of disease development (simultaneous, rather than progressive, within rows) demonstrated that the benefits achieved were not the direct result of interdiction of disease spread. These results suggest that the observed pattern of disease occurrence likely is due to spread of fungus inoculum within rows or within a few adjacent rows during plowing and cultivation, rather than by growth of the pathogen through the soil. Yield increases that resulted from use of seed mixtures likely were due to survival of disease-resistant plants within diseased sites. Superior growth of these more isolated plants might account for the greater than expected yields achieved with variety mixtures.

Yield (tons/acre) RH-3 / E-17 mixture trial 1998



Studies on *Aphanomyces cochlioides* seedling disease of sugarbeets

BSDF Project 721

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Yield losses from seedling disease caused by *Aphanomyces* cochlioides are largely avoided in Michigan through early planting into cool soils. Some A. cochlioides was isolated in 1998 from soil samples from fields with heavy stand losses. These fields, however, were planted later in the year than is optimal. The disease was not widespread in Michigan in 1998. Soil samples were taken from two heavily infested fields for later work on the population distribution of *A. cochlioides* in Michigan.

Studies on a sugarbeet seedling assay for resistance to *A. cochlioides* continued. The assay, unfortunately, gave poor discrimination between Edda, a "susceptible" variety and USH20, or ACH555, "resistant" varieties. In the assay, seedlings are infected with *A. cochlioides* zoospores, which are motile, actively sensing and swimming towards chemicals released by plant roots. With the anticipation of improving the assay, experiments were done on *A. cochlioides* zoospore production and behavior to improve reliability of the inoculum.

Zoospores were produced most abundantly in distilled water, as opposed to previously published zoospore induction media (Mitchell and Yang,) containing relatively high concentrations of various ions. Experiments were undertaken to study the effect of specific ions on zoospore production by *A. cochlioides*. Divalent cations such as Ca++, Mg++, had a deleterious effect on zoospore release. Monovalent cations such as Na+ or K+, had no or limited effects on zoospore production when compared to distilled water control.

Once zoospores are formed, it is necessary to dilute them to a predetermined concentration in order to inoculate sugarbeet seedlings and get consistent infection. Dilution with distilled water, however, caused zoospores to encyst (stop swimming). The reason for this effect is not known. Adding Ca++, Mg++, Na+ or K+ ions to the dilution media enhanced the percentage of motile zoospores in suspension, up to a point: at concentrations of 10-2 to 10-3 M, ions also caused encystment. Ions at this concentration presumably were either a stimulus to germination (zoospores must encyst before they germinate and infect a host) or high concentrations of ions provided osmotic stress (cells in solutions of lower osmotic potential tend to leak their contents) to the zoospores.

Understanding of the genetic basis for the pathogenicity of A. cochlioides has been hampered by the inability to reliably germinate oospores, the sexual propagules of this pathogen. Work is in progress to improve production of oospores in culture and to achieve more synchronous germination of oospores.

The basis for resistance or susceptibility to A. cochlioides in sugarbeet seedlings is poorly understood. Saponins are compounds present in the epidermis of sugarbeet roots which cause excessive foaming problems during sugarbeet processing. These soap-like compounds may help defend sugarbeets against pathogen attack, by disrupting cell membranes of the pathogens. Saponins in other crops, such as oats, have been shown to play an important role in defense against a broad spectrum of pathogens. Such a role for saponins in sugarbeets has not been conclusively proven. Initial work to isolate saponins from sugarbeet tissues was successful. We

observed that saponins are present in epicotyl, hypocotyl, and root tissue of seedlings, as well as in mature sugarbeet roots. Further work to adapt a quantitative assay for saponins using HPLC, as well as a large-scale extraction of sugarbeet saponins to assay their toxicity to various pathogenic fungi will be initiated in 1999.

SUGAR BEET RESEARCH

1998 REPORT

Section F

Texas Agricultural Experiment Station
Bushland, Texas

Dr. C. M. Rush, Professor

Cooperation:
Holly Sugar Corporation – Sugar Land, Texas
Western Sugar Company – Denver, Colorado

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CONTENTS

FAHNERT, M.L., G. Piccinni, C.M. Rush and L.L. New. 1998. Effects of different irrigation regimes on sugar beet growth in a pathogen infested field. Phytopathology 88:S27

A study was conducted to evaluate the effect of frequency and amount of irrigation on disease development in sugar beets. The objective of the study was to determine the optimum irrigation regimes for highest yield and percent sucrose in a soilborne pathogen infested field. There were two main irrigation regimes: a Low Energy Precision Application (LEPA) system with 100%, 75% and 50% the full rate of the pivot system, and a LEPA system with on/off valves where plots were irrigated at different frequencies. Measurements taken during the season included top fresh weight, top dry weight, root fresh weight, and number of beets per meter. Soil moisture was determined by use of a neutron probe. At harvest, root yield, number of beets per meter, disease index, percent sucrose, and stand counts were determined. Highest disease index and lowest percent sucrose occurred in plots irrigated at the full rate. However, the treatments irrigated the least had a significantly higher percent sucrose than in full rate plots. These results indicate that disease losses can be reduced and yields increased with improved irrigation management.

PICCINNI, G. and C.M. Rush. 1998. **Determination of optimum irrigation regime and water use efficiency of sugar beet.** Plant Disease, Vol. 89: (submitted)

A field and greenhouse experiment were conducted to quantify the effects of different irrigation frequencies on sugar beet yield in pathogen-infested soils. In the field experiment, four irrigation regimes (every two, three, four and five weeks) and four inoculation treatments (beet necrotic yellow vein virus - BNYVV -, beet soilborne mosaic virus - BSBMV -, BNYVV+BSBMV, and non-inoculated control) were arranged in a split-plot design replicated four times. Crop growth, soil moisture, disease severity, yield and sucrose content were evaluated. Irrigation and inoculation treatments had significant effects on both disease severity and yield. Sugar beets irrigated every four weeks showed the lowest disease severity and a yield that was not significantly different from those irrigated every two weeks. Also, sucrose content was significantly higher for beets in the four-week irrigation treatment than those irrigated every two and three weeks. Beets inoculated with BNYVV had a significantly higher disease severity and lower root yield than those inoculated with BSBMV and BNYVV+BSBMV.

The greenhouse experiment as a compliment to the field study, was conducted to evaluate the effect of irrigation amounts on disease development and water use in sugar beet. Three pathogen treatments, BNYVV, BSBMV, BNYVV+BSBMV, a non-inoculated control and three irrigation amounts, pot capacity (PC), 75% PC and 50% PC, were arranged in a split plot design and replicated five times. Pots of each treatment were weighed every other day to determine evapotranspiration. Evaporation was determined from unplanted pots, and plant transpiration was calculated by the difference. Beets irrigated at 75% pot capacity showed minimal disease incidence and a root weight comparable to the fully irrigated healthy control. Plants in the BNYVV treatment had a significantly higher disease severity than beets infected by BSBMV or BNYVV+BSBMV. Root weights and plant water use were significantly affected by inoculation treatments. Beets in the BNYVV+BSBMV treatment had a significantly higher root dry weight and water use than beets in the BNYVV treatment suggesting that BSBMV reduced the impact of disease caused by BNYVV.

MAHMOOD, T., and C. M Rush. 1998. Cross-protection between beet soil borne mosaic virus and beet necrotic yellow vein virus in sugar beet. Plant Disease, Vol. 89:(In Press)

ELISA, Western blotting, and reverse transcription-polymerase chain reaction (RT-PCR) were used to investigate the occurrence and degree of cross-protection produced in sugar beet in the greenhouse by protecting plants with beet soil borne mosaic virus (BSBMV) and challenging with beet necrotic yellow vein virus (BNYVV). Sugar beet seedlings were inoculated mechanically by vortexing in the absence of the fungus vector *Polymyxa betae*. A high degree of cross-protection occurred between BSBMV and BNYVV. The incidence of cross-protection dependents on the interval between inoculations with protecting and challenging virus; longer inoculation intervals enhanced the incidence of cross-protection. Cross-protection was most effective when inoculation interval was between 5 and 10 days, a period during which virus accumulated to a maximum level in plants singly infected with BSBMV or BNYVV. Results obtained by ELISA and Western blotting were consistent and indicated that cross-protection affected viral capsid protein. RNA of both protected and challenging viruses was detected in doubly infected plants by using RT-PCR indicating that RNA of the challenge virus was present in protected plants even though it was undetected by serological tests.

HEIDEL, G. B., and C.M. Rush. 1998. Comparison of serological tests for the detection of two soilborne sugar beet viruses. Phytopathology 88:S37

Beet necrotic yellow vein virus (BNYVV) and beet soilborne mosaic virus (BSBMV) are closely-related and often found to infest the same field. Cross reaction in serological tests used to identify the viruses is a concern when determining which virus is present. Sugar beets from seven fields in Texas and one field in Minnesota were tested for BNYVV and BSBMV by DAS ELISA, $F(ab')_2$ indirect ELISA, and a commercially-available BNYVV ELISA kit to determine consistency of results among tests. DAS and $F(ab')_2$ ELISAs used antisera developed to purified virus (BNYVV-whl, BSBMV-whl) or denatured capsid (BNYVV-den, BSBMV-den). Results of Western blot assays were used as comparison standards for BNYVV and BSBMV assay results, respectively. Among BSBMV tests, results from DAS ELISAs more closely matched those of Western blots than those obtained from the $F(ab')_2$ test using BSBMV-den antiserum. Results from the BNYVV kit test matched those of Western blots more closely than those of the DAS ELISA using BNYVV-den IgG. BNYVV and BSBMV test results, including Western results, were ranked, respectively, according to the percentage of positive results for each test for all fields. No differences were indicated among BSBMV tests. The BNYVV kit test detected more positive samples than DAS or $F(ab')_2$ ELISAs using BNYVV-den antiserum.

Determination of Optimum Irrigation Regime and Water Use Efficiency of Sugar Beet Grown in Pathogen Infested Soil

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INTRODUCTION

A field and greenhouse experiment was conducted at the Texas Agricultural Experiment Station in Bushland to quantify the effects of different irrigation regimes on sugar beet yield in pathogen-infested soils. The goal of this research was to identify the optimum irrigation regime that would minimize waste of precious irrigation water, reduce pumping expenses and at the same time maximize yield by reducing diseases.

MATERIALS AND METHODS

Field Study

Field studies were conducted at the Texas Agricultural Experiment Station in Bushland in 1996 and 1997 on ground not previously cropped to sugar beets. Sixteen twelve-row level basins were planted on May 5 and April 24 for the 1996 and 1997 crop year respectively with sugar beet variety TX18 at a seven seed per foot planting density. Four inoculation treatments BNYVV, BSBMV, BNYVV + BSBMV and a non-inoculated control were planted in two-row plots 15.24 m long. The four inoculation treatments occupied the center eight rows of each basin. At the end of each row and on each side of the level basins two filler rows were planted in order to minimize border effect. Seed were inoculated by coating them with ground root tissue containing viruliferous cystosori of *P. Betae* at the ratio of 1.5 g of inoculum; 10 g of seeds; 10 ml of methyl cellulose. Four furrow irrigation treatments, every two, three, four and five weeks were arranged in a split plot design replicated four times with irrigation treatment representing the main plot and inoculation treatment the subplot. At the end of the growing season beets from two rows in each replication, 1.5 m long, were gently pulled from the ground for disease evaluation. Beet roots were evaluated for the presence of rhizomania and or root rot like symptoms and rated on a scale form 0 to 4, where 0 represented a healthy beet and 4 a small, hairy and stunted or rotted beet. After assigning a disease rating, roots were bagged and sent to Holly Sugar, Hereford, TX for determination of weight and sugar content. After hand sampling was completed, the entire plot was mechanically topped and dug, and plot weight was determined.

RESULTS

Irrigation and inoculation treatments had significant effects on both disease severity and yield. Sugar beets irrigated every four weeks showed the lowest disease severity and a yield that was not significantly different from those irrigated every two weeks. Also, sucrose content was

significantly higher for beets in the four-week irrigation treatment than those irrigated every two and three weeks (Tables 1, 2, 3 and 4).

Table 1 Effect of irrigation treatment on number of beets per meter, yield and % sugar for the two-year field study. Values represent the mean of all inoculation treatment combined.

Irrigation [a]	Number of beets m^{-1}	Yield Mg ha^{-1}	% Sugar
2 weeks	11.04 A [b]	54.35 B	13.04 B
3 weeks	9.91 A	52.98 B	12.86 B
4 weeks	11.10 A	65.47 A	13.61 A
5 weeks	10.43 A	42.75 C	13.89 A

[a]: Basins furrow irrigated every two, three, four and five weeks.
[b]: Means followed by the same upper case letter within a column are not significantly different by Duncan's multiple range test (P=0.05).

Table 2 Effect of inoculation treatment on number of beets per meter, yield and % sugar for the two-year field study. Values represent the mean of all irrigation treatment combined.

Inoculation	Number of beets m^{-1}	Yield Mg ha^{-1}	% Sugar
Control	11.16 A [a]	54.05 A	13.71 A
BNYVV + BSBMV	10.45 A	50.91 B	13.33 B
BSBMV	10.56 A	53.86 A	13.36 B
BNYVV	10.31 A	43.32 C	13.01 C

[a]: Means followed by the same upper case letter within a column are not significantly different by Duncan's multiple range test (P=0.05).

Table 3. Effect of inoculation treatment on disease ratings of sugar beets for the two-year field study. Values represent the mean of all irrigation treatment combined.

Inoculation	1996 Disease rating [b]	1997 Disease rating
Control	0.34 C [a]	0.47 C
BNYVV + BSBMV	0.62 B	1.47 B
BSBMV	0.61 B	0.63 C
BNYVV	1.10 A	2.11 A

[a]: Means followed by the same upper case letter within a column are not significantly different by Duncan's multiple range test (P=0.05).
[b]: Disease rating is on a scale 0 – 4, where 0 represented a healthy beet and 4 a small, hairy and stunted or rotted beet.

Table 4. Effect of irrigation treatment on disease ratings of sugar beets for the two-year field study. Values represent the mean of all inoculation treatment combined.

Irrigation	1996 Disease rating [c]	1997 Disease rating
2 weeks [a]	0.83 A [b]	1.16A
3 weeks	1.00 A	1.26 A
4 weeks	0.43 B	0.70 B
5 weeks	0.54 B	0.73 B

[a]: Basins furrow irrigated every two, three, four and five weeks.
[b]: Means followed by the same upper case letter within a column are not significantly different by Duncan's multiple range test (P=0.05).
[c]: Disease rating is on a scale 0 – 4, where 0 represented a healthy beet and 4 a small, hairy and stunted or rotted beet.

GREENHOUSE STUDY

The greenhouse experiment as a compliment to the field study, was conducted to evaluate the effect of irrigation amounts on disease development and water use in sugar beet. Three pathogen treatments, BNYVV, BSBMV, BNYVV+BSBMV, a non-inoculated control and three irrigation amounts, pot capacity (PC), 75% PC and 50% PC, were arranged in a split plot design and replicated five times. Pots of each treatment were weighed every other day to determine evapotranspiration. Evaporation was determined from unplanted pots, and plant transpiration was calculated by the difference. Beets irrigated at 75% pot capacity showed minimal disease incidence and a root weight comparable to the fully irrigated healthy control. Plants in the BNYVV treatment had a significantly higher disease severity than beets infected by BSBMV or BNYVV+BSBMV. Root weights and plant water use were significantly affected by inoculation

treatments. Beets in the BNYVV+BSBMV treatment had a significantly higher root weight and water use than beets in the BNYVV treatment suggesting that BSBMV reduced the impact of disease caused by BNYVV.

Table 5. Effect of irrigation and inoculation treatments on root weight and disease rating at final harvest for the greenhouse experiment.

	Root weight (g)			Disease Index		
	PC [a b c]	75%	50%	PC	75%	50%
Control	321.06 A a	199.82 A b	139.09 A c	0.20 B a	0.70 A a	0.50 A a
BSBMV	280.58 A a	201.34 A ab	119.96 A b	1.40 A a	0.60 A a	0.90 A a
BSBMV+ BNYVV	211.22 B a	200.28 A ab	118.21 A b	1.70 A a	0.90 A b	1.00 A b
BNYVV	213.60 B a	175.68 A a	98.46 A b	2.35 A a	0.50 A b	1.00 A b

[a]: PC, 75%, and 50% represent pots irrigated at pot capacity, 75% pot capacity and 50% pot capacity respectively.
[b]: Means followed by the same upper case letter within a column are not significantly different by Duncan's multiple range test (P=0.05).
[c]: Means followed by the same lower case letter within a row are not significantly different by Duncan's multiple range test (P=0.05).
[d]: Disease rating is on a scale 0 – 4, where 0 represented a healthy beet and 4 a small, hairy and stunted or rotted beet.

Table 6. Effect of irrigation and inoculation treatments on total plant evapotranspiration for the greenhouse experiment.

	Total seasonal plant evapotranspiration (g of water)		
Inoculation	**PC [a]**	**75%**	**50%**
Control	28479 A [b]	20017 A	11722 A
BNYVV + BSBMV	26206 B	21395 A	9790 A
BSBMV	26920 B	20544 A	9249 A
BNYVV	24532 C	20440 A	11132 A

[a]: PC, 75%, and 50% represent pots irrigated at pot capacity, 75% pot capacity and 50% pot capacity respectively.
[b]: Means followed by the same upper case letter within a column are not significantly different by Duncan's multiple range test (P=0.05).

Irrigation management is a key to obtaining profitable sugar beet yields in the presence of certain "moisture loving" soil borne pathogens. Growers should pay close attention to irrigation scheduling and apply the amount of water necessary to produce good quality sugar beets without loosing yield to pathogens. Furthermore, in areas where ground water is the only available water resource, net return should be calculated considering the short term return from saving energy necessary to pump water from wells, and the long term return of preserving the aquifer.

Comparison of Serological Tests for the Detection of Two Soilborne Sugar Beet Viruses

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Introduction

Rhizomania was first reported in the United States in 1984 in California (1). It has since been identified in other sugar beet–producing states including Texas, Colorado, Wyoming, Nebraska, Idaho, and Minnesota (7,11). The disease is caused by beet necrotic yellow vein virus (BNYVV) and is characterized by heavy lateral root proliferation, overall stunting, and constriction of the tap root (8). The soilborne virus is transmitted by *Polymyxa betae* Keskin (2), and infection by BNYVV reduces yield both in percent extractable sugar and tonnage.

Beet soilborne mosaic virus (BSBMV) was first reported in Texas in 1988 (6). BSBMV and BNYVV are closely related. BSBMV, like BNYVV, is a multiparticulate virus composed of rigid, rod-shaped particles and is transmitted by *P. betae* (4,10). The RNA species and coat protein sizes of both viruses are similar. Roots of sugar beets infected with BSBMV often appear healthy, though beets have been collected that exhibit typical symptoms of rhizomania but test positive only for BSBMV. BSBMV is found to systemically infect beets in the field more frequently than BNYVV, and foliar symptoms include broad yellow vein banding and mottling. To date, studies indicate that BSBMV causes some loss of yield, but not to the extent that BNYVV does. BSBMV has been identified in the same growing areas as BNYVV (7,11).

Since these viruses are similar and are found in the same growing areas, it is important to be able to differentiate them by serological testing. BSBMV and BNYVV are serologically distinct. However, depending on test conditions and the antiserum used, cross reaction may occur (4,10). There have been conflicting results from different labs that conduct BNYVV testing on field samples. This study was conducted to compare variation in results among different serological assays used to test field beet samples. A second part of the objective was to compare variation in test results when using antiserum developed to whole virus particles or denatured capsid of BNYVV and BSBMV.

Materials and Methods

In 1997, approximately 325 beets were collected from fields in Texas and Minnesota. In 1998, 235 beets were collected from fields in Minnesota, Colorado, Nebraska, and Texas. Results presented here are for beets collected in 1997. Beets that exhibited root or foliar symptoms indicating possible infection by BSBMV or BNYVV were selected for the study. Twelve replications, 20-30 beets each, were tested.

Antisera were developed in rabbits to BNYVV and BSBMV whole virus particles or denatured capsid. IgG was fractionated from the four antisera (BNYVV-whl, BNYVV-den, BSBMV-whl, and BSBMV-den; -whl indicates antiserum developed to whole virus particles, and –den indicates antiserum developed to denatured capsid).

Two ELISAs using these antisera were evaluated. In the first type of ELISA, an indirect DAS ELISA (which will be referred to as DAS ELISA in the remainder of this paper), plates were coated with IgG, samples were probed with a secondary biotin-labeled IgG, and the secondary antibody was detected with avidin-conjugated alkaline phosphatase (4). In the second type of ELISA, $F(ab')_2$ indirect ELISA, plates were coated with $F(ab')_2$ fragments generated

from the four antisera, and samples were probed with the respective unfractionated antiserum. Protein-A conjugated alkaline phosphatase was used to detect the antiserum probe (3).

Samples were also tested by BNYVV ELISA reagents obtained from a commercial source (Bioreba Ag) and by Western blot analyses. Reagents obtained from Bioreba Ag were for a simple direct DAS ELISA. For Western blots, samples were extracted, denatured, and stored frozen until they were tested. Antiserum developed to denatured capsid of BNYVV or BSBMV were used to probe samples tested by Western blot (5,9).

Buffers used in all ELISAs were the same, and plates were incubated under the same conditions. Samples for ELISA were ground in extraction buffer at a ratio of 1:10 (w/v), and root samples prepared for Western analyses were extracted at a ratio of 1:3 (w/v).

To compare tests, Western analyses for BNYVV and BSBMV were chosen as standard tests. BNYVV and BSBMV ELISA results were compared to respective Western results on a beet-by-beet basis. If an ELISA result matched that of the same beet tested by Western blot, that was considered to be a match. The number of matches for beets tested by one ELISA from a replication were counted and converted to a percentage (number of matches divided by the number of beets tested). Data were analyzed to determine if results of any test matched those of Western blot analyses more closely than other test results.

To determine if any test (including Western blot) was consistently detecting the highest number of positive samples, tests were ranked by replication in terms of which test detected the highest percentage of positive samples. A ranking of 1 was assigned to the test or tests that detected the highest percentage of positive samples, and rankings of 2, 3, etc., were assigned to tests that detected lower percentages of positive samples, respectively, within a replication. Tests detecting the same percentage of positive samples within a replication were assigned equal rankings.

Results and Discussion

The percentage of positive samples, by test and replication, are indicated in Table 1. Most replications included beets positive for BNYVV and/or BSBMV.

Percentage of matching results for BSBMV tests and the range of percent matches for each test are in Table 2. Results of beets tested by DAS ELISA using BSBMV-whl and BSBMV-den antisera matched those of Western blot analyses more closely than results from $F(ab')_2$ ELISA using BSBMV-den antiserum. The range of percent matches was from 15-100 for all tests. In three $F(ab')_2$ BSBMV-den ELISA replications, fewer than 25% of the results matched those of beets tested by Western blot. In these replications, Western blot analyses and the other ELISAs usually indicated that most of the beets were negative for BSBMV; this test indicated that most of the beets were positive for BSBMV.

Among BNYVV tests (Table 3), results of DAS ELISA using antiserum developed to BNYVV denatured capsid matched those of Western blot analyses significantly less frequently than results of all other ELISAs. No differences in percentage of matching results were indicated among the other four tests.

Future analyses of the data will take into consideration how results of ELISA tests varied from those of Western blot analyses. In other words, ELISA results not matching Western results will be scored in terms of whether the ELISA result was positive and the Western result was negative, or vice versa.

Rankings of test results for BSBMV and BNYVV are in Tables 4 and 5. Among BSBMV tests, DAS ELISA using antiserum developed to whole virus particles detected the

Table 1. Percentage of beet root samples positive for BNYVV or BSBMV. Approximately 20-30 beets per replication were tested.

	DAS		Comm.[2]	Western		DAS		F(ab')$_2$			
Test	T-den[1]	B-den	BNYVV	T-den	B-den	B-whl	T-whl	B-whl	B-den	T-whl	T-den
Replication											
EBS	11	64	86	7	86	79	0	79	71	39	93
WBS	14	34	97[3]	24	83	100	14	93[3]	86	21	69
TEA	33	57	73	57	80	70	30	63[3]	60	33	40
F 9-26	95	81	71	95	48	86	90	86[3]	62	95	100
BMN	17	97	100[4]	33	83	90	27	97[4]	100	27	7
F10-10	81	95	95	76	86	95	81	33[3]	67[3]	52	67
FHP	10	63	100	20	100	97	10	100[4]	73	50	33
N 9-26	55	75	90	30	45	90	45	80[4]	75	55	50
EBS 3	7	83	79	3	53	90	20	83	62	59	79
DFR	57	93	100[3,4]	17	83	100	27	87[3,4]	100	70	100
EAC	37	20	43[3,4]	10	0	30	7	0[3,4]	0	0	0
SBS	58	25	100[4]	24	90	100	23	89[3,4]	46	32	71

[1]T indicates BSBMV (TX7); B indicates BNYVV; –den indicates antiserum developed to denatured capsid; –whl indicates antiserum developed to whole virus particles.
[2]ELISA reagents obtained from a commercial source.
[3]BSBMV control tested positive.
[4]BSBMV-like isolate (RC) tested positive.

Table 2. Percentage of BSBMV ELISA results matching those of Western blot analyses.

ELISA	Antiserum	% Match	Range[2]
DAS	-whl[1]	83.8 a	67-95
DAS	-den	75.4 ab	47-97
F(ab')$_2$	-whl	70.1 b	41-100
F(ab')$_2$	-den	56.0 c	15-95

[1]-whl indicates antiserum developed to whole virus particles; -den indicates antiserum developed to denatured capsid.
[2]Range indicates the highest and lowest percent match values.

Table 3. Percentage of BNYVV ELISA results matching those of Western blot analyses.

ELISA	Antiserum	% Match	Range[3]
Comm.[1]	-	79.0 a	55-100
DAS	-whl[2]	76.3 a	52-97
F(ab')$_2$	-whl	74.3 a	35-100
F(ab')$_2$	-den	73.3 a	50-100
DAS	-den	58.1 b	21-81

[1]Commercially available BNYVV ELISA reagents.
[2]-whl indicates antiserum developed to whole virus particles; -den indicates antiserum developed to denatured capsid.
[3]Range indicates the highest and lowest percent match values.

Table 4. Rankings of test results based on percentage of beets testing positive for BSBMV within a field[1].

Assay	Antiserum	Rank
$F(ab')_2$	-den[2]	1.9 a
$F(ab')_2$	-whl	2.4 b
DAS	-den	2.6 b
Western	-den	2.9 c
DAS	-whl	3.4 d

[1]A ranking of 1 was assigned to the test within a replication that detected the highest percentage of positive samples. Rankings increased numerically as the percentage of positive samples indicated by a test decreased.

[2]-den indicates antiserum developed to denatured capsid; -whl indicates antiserum developed to whole virus particles.

Table 5. Rankings of test results based on percentage of beets testing positive for BNYVV within a field[1].

Assay	Antiserum	Rank
Comm.[2]	-	1.5 a
DAS	-whl[3]	1.6 a
$F(ab')_2$	-whl	2.6 b
Western	-den	3.2 c
$F(ab')_2$	-den	3.3 c
DAS	-den	3.3 c

[1]A ranking of 1 was assigned to the test within a replication that detected the highest percentage of positive samples. Rankings increased numerically as the percentage of positive samples indicated by a test decreased.

[2]Commercially available BNYVV ELISA reagents.

[3]-whl indicates antiserum developed to whole virus particles; -den indicates antiserum developed to denatured capsid.

highest percentage of positive samples least often, and $F(ab')_2$ ELISA using antiserum developed to denatured capsid detected the highest percentage of positive samples most frequently. Among BNYVV tests, ELISA using commercial reagents and DAS ELISA using antiserum developed to whole virus particles detected the highest number of positive samples more frequently than other tests. No differences were indicated in rankings among Western analyses and $F(ab')_2$ and DAS ELISAs using antiserum developed to denatured capsid.

The weakness in ranking data in this way is that information on how much the values of percentage of positive samples detected varied among tests within a replication was not indicated. Rankings of 1 and 2 might mean that one test detected 90% positive samples and another test detected 60% positive samples. Or rankings of 1 and 2 might mean that one test detected 35% positive samples and another test detected 34% positive samples. A way to avoid this would be to group percent positive values into class rankings and assign numerical rankings to different classes instead of to individual scores.

Cross-reaction has been reported previously between BNYVV and BSBMV, depending on the test, test conditions, and antiserum used (4,10). BNYVV and BSBMV controls were included in all tests used in this study, and, for most tests, controls reacted as expected. However, in seven $F(ab')_2$ ELISAs using BNYVV-whl antiserum, one $F(ab')_2$ ELISA using BNYVV-den antiserum, and three commercial BNYVV tests, the BSBMV control tested positive. In six $F(ab')_2$ ELISAs using BNYVV-whl antiserum and four commercial BNYVV tests, an isolate referred to as RC reacted positively. RC typically reacts positively for BSBMV, but with a much weaker reaction than a standard BSBMV positive control. Tests which

indicated cross reactions mentioned above are noted in Table 1. For the most part, cross reaction was not observed in control samples.

Given the potential for cross reaction between BNYVV and BSBMV, it is important to include a BSBMV positive control in BNYVV tests and vice versa, particularly when evaluating new assays. When testing samples collected in 1998, reagents for BNYVV ELISA were obtained from a commercial supplier different from the one used in 1997 tests. At the manufacturer's recommended 1:100 dilution of BNYVV IgG and alkaline phosphatase-conjugated IgG, there was a strong positive reaction by the BSBMV control. When reagents were diluted to 1:750, results were similar to those obtained using Bioreba Ag reagents.

A possible reason for variation in test results observed could be differences that can occur among ELISAs in terms of sensitivity and specificity. It has been reported that indirect ELISAs, such as $F(ab')_2$ tests, can be more sensitive and less specific than direct DAS ELISAs. $F(ab')_2$ tests can detect a broader range of serologically related viruses (3).

Even though variation in results occurred, most ELISA results were within 70-80% agreement of Western results. For speed and ease of handling large numbers of samples, ELISA is a suitable test. However, samples should be tested in more than one way if results are in question.

Use of assays which incorporate molecular probes specific for BNYVV and BSBMV would provide further verification of serological results. Northern hybridization and RT-PCR would be appropriate tests. However, RT-PCR would be more sensitive and better suited to detect BNYVV or BSBMV in field beet samples in which the titer might be low and difficult to detect by Northern hybridization.

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SUGARBEET RESEARCH

1998 Report

Section G

Molecular Plant Pathology Laboratory

Agricultural Research Service

United States Department of Agriculture

Beltsville, Maryland

Dr. Ann C. Smigocki, Research Geneticist

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CONTENTS

PUBLICATIONS

Smigocki, A.C., S. Heu, I. McCanna, C. Wozniak and G. Buta. Insect resistance induced by overproduction of the plant growth regulator cytokinin in ipt transgenic plants. Plant Molecular Biology, (submitted)

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Selected abstracts of papers published or approved for publication:

TRANSGENIC SUGARBEET (BETA VULGARIS) ENGINEERED FOR PRODUCTION OF HIGH CYTOKININ LEVELS INVOLVED IN DEFENSE RESPONSES AND CARBON PARTITIONING Snezana D. Ivic Molecular Plant Pathology Laboratory, USDA-ARS, BARC-West, Beltsville, MD 20705 Iris J. McCanna Molecular Plant Pathology Laboratory, Richard C. Sicher Climate Stress Laboratory and Ann C. Smigocki Molecular Plant Pathology Laboratory

Cytokinins as major plant growth regulators are involved in a wide range of physiological and biochemical processes. They upregulate secondary metabolic pathways, products of which have insecticidal and antimicrobial properties. In sugarbeet taproots, increased cytokinin levels have been correlated with cambial initiation and rapid cell division periods. To increase endogenous cytokinins in sugarbeet, a bacterial cytokinin biosynthesis gene, *ipt* ,was fused to a wound-inducible proteinase inhibitor II (Pin2) or a tuber-specific patatin (Pa) gene promotor from potato. *Agrobacterium*-mediated cotyledon transformation or particle bombardment of embryogenic callus yielded one Pin2-*ipt* and two Pa-*ipt* plants. Putative transformants were identified by PCR and placed on root inducing medium. To compensate for the elevated cytokinin levels, two previously obtained Pa-*ipt* shoots were exposed to high auxin concentrations (50 mg IBA/ml) for a 24 hour period for root initiation as compared to continuous 3 mg IBA/ml for normal shoots. Pa-*ipt* shoots rooted in 4-8 weeks in comparison to 2 weeks for controls. One of the transformants appeared normal except for increased adventitious shoot development and the other exhibited dark green leaves and reduced apical dominance, all typical cytokinin effects. Approximately a 3 fold increase in sucrose levels was observed in the dark green leaves but the taproot levels were unchanged. Levels of the cytokinins zeatin and zeatinriboside in leaves and taproots of the Pa-*ipt* transformants were up to 20 and 2 times higher, respectively, than in normal plants. Analyses of the transgenic plants for resistance to the sugarbeet root maggot and sucrose content are in progress.

ANALYSIS OF DIGESTIVE PROTEINASES FROM MIDGUTS OF THE ALFALFA WEEVIL HYPERA POSTICA (COLEOPTERA: CURCULIONIDAE) AND CLONING OF CYSTEINE PROTEINASE GENES Stephen E. Wilhite, Ann C. Smigocki, and Thomas C. Elden. USDA, ARS, Plant Sciences Institute, Soybean and Alfalfa Research Laboratory, Beltsville, MD, 20705

Insects rely on a variety of midgut proteinases to catalyze the release of free amino acids from dietary protein and thereby provide nutrients essential for normal growth and development. A potential for insect control has been demonstrated in laboratory studies involving the expression of proteinase inhibitor (PI) genes in transgenic plants. However, insects have revealed an ability to compensate for lost proteinolytic activity by enhancing production of proteinases insensitive to the introduced PI. Thus, there is a need to characterize the individual proteolytic enzymes within an insect in order to pursue a directed control strategy in which each proteolytic activity is specifically targeted for inhibition. Proteinases isolated from dissected midguts of Hypera postica are being analyzed using gelatin-containing SDS-PAGE and class-specific PIs. A parallel approach is being pursued to clone cysteine proteinase (CP) genes, as previous studies have indicated that CPs play a prominent role in the digestive ability of this insect. DNA primer mixtures corresponding to evolutionarily conserved regions of amino acids within CPs were synthesized for use in PCR. Templates included DNA from H. postica, as well as DNA from the dipteran insects Tetanops myopaeformis (sugarbeet root maggot) and Drosophila melanogaster (fruit fly) as positive control. Fragments of about 500bp have been amplified from each of these templates. Subcloning followed by selection, propagation, and sequencing of individual clones derived from each template can be expected to reveal one or more cysteine proteinase genes for each organism. These genes will ultimately serve as tools to express recombinant CP for selecting potent inhibitors from a library of novel CP inhibitors.

CLONING OF CYSTEINE PROTEINASE GENES FROM THE ALFALFA WEEVIL *HYPERA POSTICA* (COLEOPTERA: CURCULIONIDAE) Stephen E. Wilhite, Ann C. Smigocki, and Thomas C. Elden. USDA, ARS, Plant Sciences Institute, Soybean and Alfalfa Research Laboratory, Beltsville, MD, 20705

Digestive proteinases of insects catalyze the release of free amino acids from dietary protein and thereby provide a supply of nutrients essential for normal growth and development. A possible approach to insect control is to express proteinase inhibitor (PI) genes in transgenic plants. Plant PIs have been shown in artificial feeding bioassays, as well as in transgenic plants, to inhibit gut proteinases and interfere with normal growth and development of insects. However, effective protection is likely to require multiple PIs directed against individual proteolytic activities in the insect gut. This problem is apparent in the growing number of instances in which insects exposed to a particular PI compensate by producing proteinases insensitive to that PI. Thus, the objective here is to identify multiple proteinase genes that may be involved in digestion. This will allow us to pursue an insect control strategy in which specific gut proteinases are targeted by PIs that are both specific and potent. To amplify cysteine proteinase genes, degenerate primer mixtures corresponding to evolutionarily conserved regions of amino acids within the enzymes were synthesized. These primers were used in PCR to amplify the corresponding region of the proteinase genes from a genomic DNA template. Templates included DNA from *Hypera postica,* as well as DNA from the dipteran insects *Tetanops myopaeformis* (sugarbeet root maggot) and *Drosophila melanogaster* (fruit fly) as positive control. Fragments of about 500bp have been amplified from each of these templates. Subcloning followed by selection, propagation, and sequencing of individual clones derived from each template can be expected to reveal one or more cysteine proteinase genes for each organism. Results will be presented.

CLONING AND EXPRESSION ANALYSIS OF A WOUND-INDUCIBLE CYTOCHROME P450 FROM HORNWORM-INFESTED AND MECHANICALLY WOUNDED LEAVES OF IPT-TRANSFORMED NICOTIANA PLUMBAGINIFOLIA. Cesar V. Mujer and Ann C. Smigocki. Molecular Plant Pathology Laboratory, USDA-ARS, BARC-West, Beltsville, MD 20705

Cytochrome P450 monooxygenases heme-containing enzymes that mediate a wide range of oxidative reactions involved in the biosynthetic, catabolic and detoxification pathways of all living organisms. Plant P450s catalyze the synthesis of a variety of secondary products, some of which are shown to inhibit insects, pathogens and animal herbivores. Using RT-PCR of total RNA from Nicotiana plumbaginifolia transformed with the isopentenyl transferase (ipt) gene that is fused to a wound-inducible promoter, two full length clones of P450 were isolated and sequenced. One of the clones is bigger than the other by 81 nucleotides and its predicted 508 amino acid sequence has 44% identity to Catharanthus roseus P450 (CYP72), a protein exhibiting geraniol 10-hydroxylase activity. When in vitro transcribed and translated, two 35S-met or 3H-leu labeled polypeptides with molecular masses of 53 and 34 kDa were obtained using clones 1 and 2, respectively. The expression of P450 is regulated by light and darkness. Northern blot analysis revealed that transcript accumulation was maximum during mid-day but was lowest at night. Hornworm (Manduca sexta) feeding and mechanical wounding disrupted this rhythm resulting in an elevated level of expression at night in the wounded leaf. The level of induction was 4-to 6- fold higher in ipt-transformed leaves after 6-12 hr of mechanical wounding in comparison to 2- to -3.5 fold induction from wounded but untransformed leaves. The response to insect feeding and mechanical wounding was systemic and was detected maximally in the leaf immediately above the damaged leaf. P450 transcripts were not detected in flower buds, flowers and seed pods. The role of P450 in plant defense responses will be explored by transforming plants with various P450 sense and antisense constructs.

MOLECULAR CLONING AND CHARACTERIZATION OF A WOUND-INDUCIBLE CYTOCHROME P450 FROM *NICOTIANA PLUMBAGINIFOLIA*. TRANSFORMED WITH THE BACTERIAL ISOPENTENYL TRANSFERASE GENE. Cesar V. Mujer and Ann C. Smigocki. Plant Sciences Institute, Molecular Plant Pathology Laboratory, USDA-ARS, Beltsville, MD 20705

Plant cytochrome P450 monooxygenases are heme-containing enzymes that participate in the synthesis of a wide variety of secondary products, some of which are shown to inhibit insects, pathogens and animal herbivores. Using reverse transcription-polymerase chain reaction (RT-PCR) of poly(A)$^+$ RNA from *Nicotiana plumbaginifolia* containing the potato inhibitor wound-inducible promoter-isopentenyl transferase gene construct (PI-II-*ipt*), two full length clones of P450, designated as pNpl1 and pNpl2, were isolated and sequenced. Npl1 has an open reading frame of 1524 nucleotides corresponding to 508 amino acids and its deduced amino acid sequence has 44% identity to Catharanthus roseus P450 (CYP72). PNpl2 is similar to pNpl1 except for 81 nucleotides deletion and an internal stop codon, and so possibly represents a pseudogene. When *in vitro* transcribed and translated, two ^{35}S-methionine labeled polypeptides with molecular masses of 56 and 34 kDa were synthesized corresponding to the products of pNpl1 and pNpl2, respectively. The complete coding region of pNpl1 was amplified by PCR and used to estimate the copy number of P450 genes and to study the expression of P450 in PI-II-*ipt*-transformed and normal *N. plumbaginifolia*. Southern blot hybridization of genomic DNA indicated that P450 exists as multiple copies of the same gene. The expression of P450 is regulated by light and darkness. Northern blot analysis revealed that transcript accumulation was maximum during the day but was lowest at night. When infested with tomato hornworm (*Manduca sexta*) larvae or mechanically wounded, this rhythm was disrupted resulting in an elevated level of expression at night in the wounded leaves. The level of induction was 4-to 6- fold higher in PI-II-*ipt*--transformed leaves after 6-12 hr of mechanical wounding in comparison to 2- to -3.5 fold induction from wounded but untransformed leaves. The response to feeding insect larvae was systemic and was detected maximally in the leaf immediately above the damaged leaf. P450 transcripts were not detected in flower buds, flowers and seed pods. Polyclonal antibodies were raised against a cocktail of three synthetic peptides whose sequences corresponded to internal regions of the deduced P450 protein exhibiting high antigenic indices. Preliminary western blot analysis of cell-free extracts indicated the presence of 58.8 kDa P450 proteins in tobacco, periwinkle, sugarbeet and soybean leaves. The modulation of P450 gene expression by cytokinins and the possible role of P450 in plant defense responses are discussed.

ISOLATION OF A CYSTEINE PROTEINASE cDNA FROM THE ALFALFA WEEVIL AND ANALYSIS OF ITS MIDGUT PROTEINASES Stephen E. Wilhite1, Ann C. Smigocki2, and Thomas C. Elden1. USDA, ARS, Plant Sciences Institute, Soybean and Alfalfa Research Laboratory1 and Molecular Plant Pathology Laboratory2, Beltsville, MD 20705

Insects rely on a variety of midgut proteinases to catalyze the release of free amino acids from dietary protein and thereby provide nutrients essential for normal growth and development. A potential for insect control has been demonstrated in laboratory studies involving the expression of proteinase inhibitor (PI) genes in transgenic plants. However, insects have revealed an ability to compensate for lost proteinolytic activity by enhancing production of proteinases insensitive to the introduced PI. Thus, there is a need to characterize the individual proteolytic enzymes within an insect in order to pursue a directed control strategy in which each proteolytic activity is specifically targeted for inhibition. We are conducting both biochemical and molecular cloning experiments to elucidate the digestive proteinases of *Hypera postica*. Gelatin-containing SDS-PAGE of weevil midgut extracts has revealed one major and several minor size-classes of proteolytic activity. The large majority (70-80%) of proteolytic activity appears to result from cysteine proteinases in the midgut extract, as revealed by inhibition of the enzymatic activity with class-specific protease inhibitors. Of interest from the standpoint of pest control, the recombinant rice inhibitors OCI and OCII were similarly effective at inhibiting proteolytic activity as the potent, irreversible cysteine proteinase inhibitor E-64. One cysteine proteinase clone has been identified in a random sampling of 10 lambda clones from an *H. postica* midgut-specific cDNA library. DNA sequencing of the

insert has revealed a full-length cDNA (*hcp1*) encoding a predicted protein (HCP1) of 324 amino acids. This putative digestive enzyme is highly similar to cathepsin L-type cysteine proteases, and is predicted to play an important role in the assimilation of dietary protein in the alfalfa weevil.

WOUND-INDUCIBLE CYTOCHROME P450 FROM *NICOTIANA PLUMBAGINIFOLIA* TRANSFORMED WITH THE *IPT* GENE INVOLVED IN CYTOKININ BIOSYNTHESIS Cesar V. Mujer and Ann C. Smigocki Molecular Plant Pathology Laboratory, Agricultural Research Service, U.S. Department of Agriculture, Beltsville, MD 20705, USA.

Two cDNA clones with high sequence similarity to cytochrome P450 monooxygenases were isolated using reverse transcription-polymerase chain reaction (RT-PCR) of poly(A)$^+$ RNA from *Nicotiana plumbaginifolia* transformed with a wound inducible cytokinin biosynthesis gene construct (PI-II-*ipt*). *CYP*72A2 has an open reading frame of 1524 nucleotides and its deduced 508 amino acid sequence has 45% identity to *Catharanthus roseus* P450 (*CYP*72A1). The other clone (*npl*2) is similar to *CYP*72A2 except for an 82-nucleotide deletion and an internal stop codon. *In vitro* transcription and translation of *CYP*72A2 and *npl*2 generated two ^{35}S-methionine labeled polypeptides of 56 and 34 kDa, respectively. *CYP*72A2 was shown to be a member of a small gene family and its transcript levels increased in response to mechanical wounding or feeding by tobacco hornworm (*Manduca sexta*) larvae. In PI-II-*ipt*-transformed leaves, a 4.5- to 6-fold induction was observed at 6 to 12 h after mechanical wounding in comparison to a 2- to 3.5-fold induction in wounded, untransformed leaves. This was a systemic response but maximum induction occurred sooner in the transgenic plants. Using polyclonal antibodies raised against three internal regions of the deduced CYP72A2 protein, a 58.8 kDa polypeptide was detected in leaves of *N. plumbaginifolia*, tobacco, periwinkle, sugarbeet and soybean. The modulation of *CYP*72A2 expression by cytokinins and the possible role of P450 in plant defense responses are discussed.

SYSTEMIC INDUCTION OF CYTOCHROME P450 GENE IN *IPT*-TRANSFORMED *NICOTIANA PLUMBAGINIFOLIA* BY HORNWORM (*MANDUCA SEXTA*) FEEDING AND MECHANICAL WOUNDING Cesar V. Mujer and Ann C. Smigocki. USDA, ARS, Plant Sciences Institute, Molecular Plant Pathology Laboratory, Beltsville, MD, 20705

Cytochrome P450 monooxygenases are heme dependent mixed function oxidases that utilize NADPH or NADH and molecular oxygen to produce functionalized organic products. In higher plants, P450 monooxygenases are involved not only in the biosynthesis of secondary metabolites but also in the metabolism of xenobiotics including herbicides and insecticides. Using 5'RACE, the cloning and reconstruction of the full length sequence of a P450 cDNA clone from *N. plumbaginifolia* has been reported (LaRosa and Smigocki, 1996). This cDNA clone hybridized to an mRNA transcript whose abundance rose moderately in *N. plumbaginifolia* containing a heat-shock inducible isopentenyl transferase (*ipt*) gene construct. In this study, we investigated the effect of hornworm feeding and mechanical wounding on P450 gene expression using tobacco plants containing a wound inducible *ipt* gene construct. Northern blot analysis showed a 4- to 6-fold higher levels of induction after 6 to 12 hr of mechanical wounding in *ipt*-transformed leaves at various stages of development in comparison to a 2- to 3.5-fold induction from wounded but untransformed leaves. Leaves infested with third instar hornworm (*Manduca sexta*) larvae elicited a response similar to that caused by mechanical wounding. The response to both treatments was systemic and was detected maximally in the leaf immediately above the damaged leaf. P450 transcripts were not detected in flower buds, flowers and seed pods. The possible role of P450 in plant defense will be explored by transforming *N. plumbaginifolia* with a wound inducible-P450 antisense constructs.

Gene Transfer to Optimize the Sucrose Storage Capacity of the Sugarbeet Taproot

BSDF Project 810

Ann C. Smigocki

A number of studies have concluded that in order to optimize the sucrose storage capacity of the sugarbeet taproot its structure would have to be modified to contain more vascular zones with shorter distances between the phloem and the storage vacuoles. Changes in phytohormone profiles of sugarbeet taproots between sowing and harvest have been determined and related to initiation of cambia, cell division of the cambia and rapid cell expansion stages in root development. It is well established that cytokinins induce cell division and in taproot-derived sugarbeet suspension cultures, cytokinin levels were shown to peak just prior to cytokinesis. These results suggest that higher cytokinin levels in the taproot will lead to increased cell division, additional vascular rings and increased sucrose yield. In addition, cytokinins have been identified as having functional significance in the control of assimilate movement in plants, particularly by altering phloem unloading, sink initiation, and sink strength and capacity. Since field applications of phytohormones are of limited value due to high costs and rapid degradation, we have genetically engineered sugarbeets for production of high cytokinin levels in the taproot. To increase endogenous cytokinins in the taproot, a bacterial cytokinin biosynthesis gene *ipt* was fused to a tuber-specific promoter from the patatin gene of potato and introduced into sugarbeet using an *Agrobacterium*-mediated cotyledon transformation method or particle bombardment of embryogenic hypocotyl callus. Regenerated shoots required high auxin concentrations for rooting, presumably to compensate for the elevated cytokinin levels. Transformants appeared normal except for more adventitious shoot development or exhibited reduced apcial dominance and dark green leaves, all typical of cytokinin effects. Cytokinin levels in taproots and leaves were up to 2

and 17 times higher, respectively. In one of these transgenic plants, leaf sucrose levels were 9 times higher than in the control. Surcose concentrations in the taproots were 20 to 50% higher. These preliminary results support the hypothesis that higher cytokinin levels increase sucrose accumulation in leaves and taproots of transgenic plants.

Engineering sugarbeets with multiple proteinase inhibitor genes for enhanced tolerance to the sugarbeet root maggot

BSDF Project 811

Ann C. Smigocki

One of the most devastating pest of sugarbeet in the U.S. is the root maggot (*Tetanops myopaeformis* Roder). Losses can be as high as 23% in infested fields and are speculated to increase in the next few years due to the anticipated removal of all chemical pesticides effective against the maggot from EPA approved registrations. Currently no biological control measures are available. Introduction of multiple resistance genes into transgenic plants will most likely prove to be the most effective and perhaps sustained means of controlling diseases and insect infestations. One approach to insect control is to express proteinase inhibitor genes in transgenic plants to specifically target the insect's digestive proteases leading to inhibition of catalysis of dietary proteins essential for normal insect growth and development. To target the sugarbeet root maggot, we are in the process of determining the nature of the maggot's digestive proteases. Extracts of midguts excised from feeding second instar larvae were analyzed for specific protease classes using an inhibition assay. Most of the gut protease activity was inhibited by proteinase inhibitors specific for two classes of proteases. Further research is in progress to identify specific proteinase inhibitor genes for introduction into sugarbeet.

We have designed degenerative oligonucleotide primer mixtures from alignments of

proteases from various organisms and have PCR amplified DNA fragments from the SBRM genomic DNA that are highly homologous at the amino acid level to the digestive proteases from two Dipteran insects, the flesh and fruit fly. In a collaborative effort with Steve Gleddie (Agriculture and Agri-Food Canada, Ottawa, Ontario), our goal is to screen phage display libraries of mutated proteinase inhibitor genes to select the most effective inhibitor specific for the cloned maggot proteases. Clones of the most potent inhibitors will then be reconstructed for optimal expression and introduced alone or in pairs into sugarbeet.

Sugar Beet Bioengineering for *Cercospora beticola* Resistance and Decreased Susceptibility to Other Microbial Plant Pathogens

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Summary

A strategy of using a fungal gene for cercosporin transport (*cfp*) for enhancing sugar beet resistance to *Cercospora* leaf spot disease was proposed. The *cfp* gene and it's nucleotide sequence were obtained from Greg Upchurch at North Carolina State University, Raleigh, NC. Plasmid X, which carries *cfp,* was transformed into *E. coli* HB101 in order to increase the quantity of DNA available for *in vitro* manipulations. Restriction enzyme digestion and agarose gel electrophoresis were used to verify the *cfp* gene. Suitable plant promoter sequences are being used to construct a "fused" gene(s) that will be adequately expressed in sugar beet leaves and which is nonproprietary so that new transgenic plants made with these constructs can be freely released as germplasm for use by breeders.

Transgenic sugar beet plants carrying introduced genes specifying antimicrobial peptides were examined under axenic conditions, free of possible complications since other microbes are absent, for their ability to inhibit the growth of *Cercospora beticola*, the microorganism responsible for leafspot disease in sugar beet. Transgenic clone OOT has recently been identified as a potential candidate that may adequately express the production of a potent antimicrobial peptide. This novel genotype has a barley thionin gene and the tobacco osmotin gene both under the wound-inducible control of the osmotin promoter. Plants are currently being grown for greenhouse evaluation. *In vitro* analyses were complicated by the fact that most of the new sugar beet genotypes as well as the parental germplasm, REL-1, stimulated the growth of *C. beticola* on chemically defined medium and other artificial conditions. Perhaps it is not surprising that axenic sugar beet shoot segments supply phytopathogenic fungi with growth factors.

Rhizosphere bacteria from North Dakota, obtained from healthy sugar beets by John Eide and Garry Smith of the Fargo Sugar Beet Lab, are being purified and examined for their potential in biocontrol of sugar beet pathogens and as a new source of transgenes that could confer leafspot disease resistance by producing specific antimicrobial products. These interesting soil bacteria, which could also have potential as plant growth-promoting rhizobacteria (PGPR), are also being microbiologically characterized.

In vitro studies

Thorough examination of all the available data obtained in various *in vitro* studies conducted this year revealed that transgenic clone OOT potentially can inhibit *Cercospora beticola*. This novel genotype is deserving of further investigation and so experiments are planned using clonal plants propogated in the greenhouse.

A series of *in vitro* pathogen/ sugar beet interaction studies were done and the co-cultivation of *Cercospora beticola* with *Beta vulgaris* genotypes produced some interesting results which were interpreted as indicative of variable growth inhibition of *Cercospora* by selected novel genotypes. Apparent fungal inhibition was evident when the distance from fungal pathogen to shoot segment was less than 1.0 cm.

Results obtained with plates on which two axenic shoot segments were placed, one directly inoculated with *Cercospora* and one uninoculated, showed that the *Cercospora* fungi grew rapidly and, within 7 days of incubation, covered the entire inoculated shoot segment.

Interestingly, one novel sugar beet genotype, namely the Osm-*osm* transgenic, was evidently a very favorable substrate for the growth of *Cercospora* since leaf segments of this genotype were covered entirely by white fungal mycelia within five days of incubation compared with a 7-day incubation period required for similar fungal growth on leaf squares from axenic shoot cultures of the other transgenic sugar beet genotypes or from those of the parental genotype.

Also there was stimulation of the growth of *Cercospora* by axenic sugar beet leaf pieces as a factor complicating the interpretation of *in vitro* analyses of growth inhibition. When four 3x7 mm leaf segments were placed at equal distances of about 3.5 cm from the point of *Cercospora beticola* inoculation, they stimulated the fungus to grow to a diameter of about 3.9 cm in 14 days, a large increase over the colony size of approximately 1.8 cm on the control plate with *Cercospora* inoculation but without the presence of any axenic sugar beet leaf segments.

Axenic, excised sugar beet leaf segments evidently release into the medium diffusible substances that dramatically stimulate *Cercospora* growth. This phenomenon seriously complicated our attempts to test transgenic sugar beets, which carried introduced genes specifying the production of antimicrobial peptides, for their ability to inhibit *Cercospora.*

Without the presence of sugar beet tissues, pure cultures of the fungal pathogen *Cercospora beticola* developed on two very different culture media at different growth rates. All four single-spore *C. beticola* isolates obtained from Earl Ruppel in Fort Collins, CO, grew more rapidly and extensively on nutrient-rich potato dextrose agar (PDA) than on the chemically defined tissue culture medium (TCM) (Table 1). Unlike PDA, TCM does not contain all of the nutrients needed to support good growth of *Cercospora. Cercospora* is a relatively slow-growing fungus and it has a requirement for a number of nutrients. It is not unusual for a plant pathogen to require a variety of nutritional or growth factors since *Cercospora rosicola* is known to require a large number of the amino acids and vitamins.

Table 1: Colony Diameter in Centimeters of Pure Cultures of Four *Cercospora beticola* Strains After Two Weeks Incubation on Two Very Different Media*

Cercospora Strain	PDA	TCM
C1	3.8	1.0
C2	4.4	1.5
H1-12	4.4	1.7
F 573	4.1	1.2

* Values are the means of four replicates.

Bill Belknap of the Albany Plant Gene Expression Center and Jeff Buyer of the Beltsville Soil Microbial Systems Lab have been asked to collaborate on gene fusions and the characterization of potential biocontrol bacteria originating in the rhizospheres of healthy sugar beets in production fields, respectively.

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Publications

Kuykendall, L.D. and Ann C. Smigocki. 1999. *Cercospora beticola* interactions with axenic sugar beet cultures. Preceedings of the American Society of Sugar Beet Technologists Biennial Meeting (in press).

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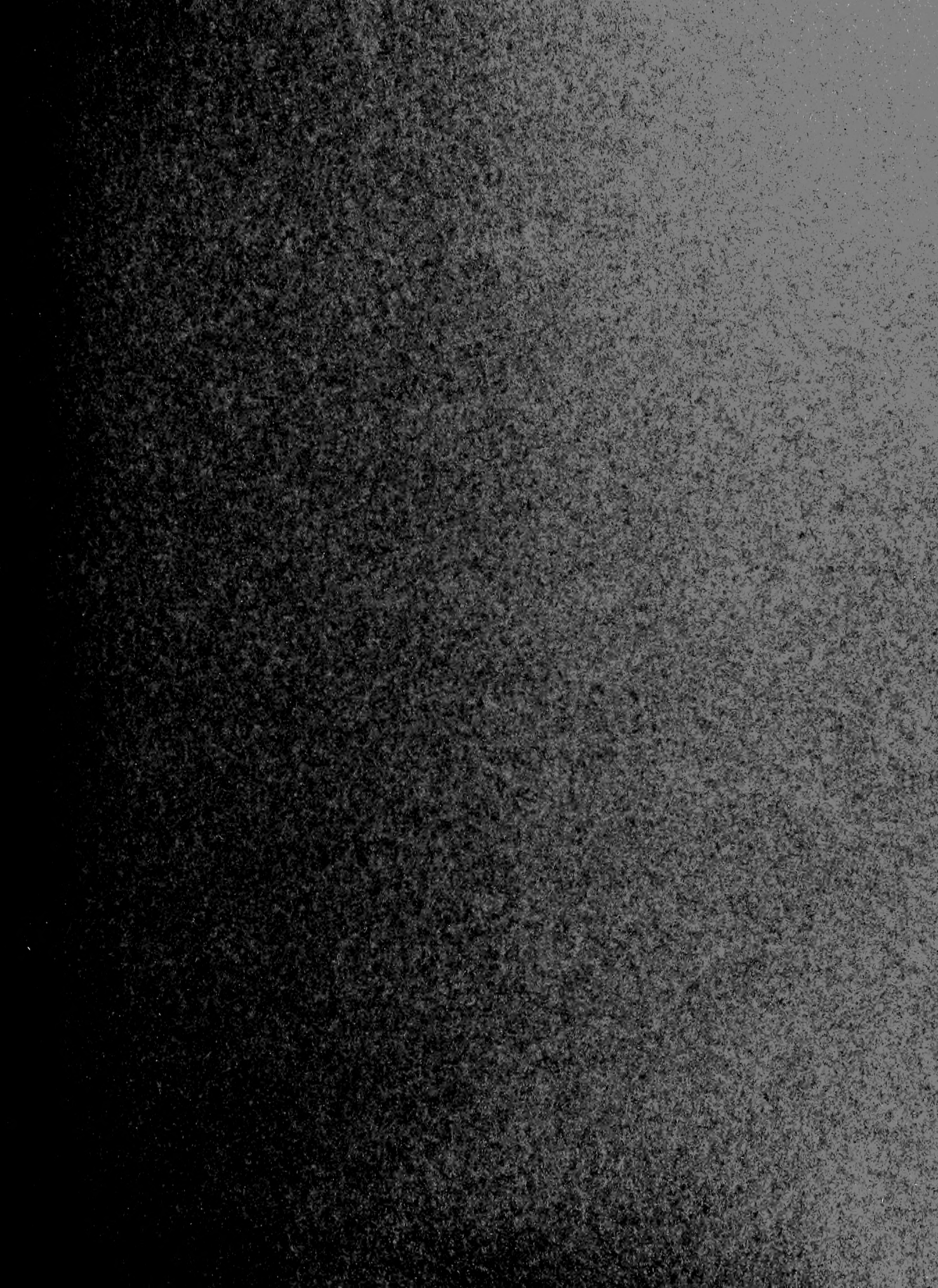

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